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ORIGINAL ARTICLES.

I.—Note on some Vertebrate Remains collected in the Fayûm, Egypt, in 1906.

By C. W. Andrews, D.Sc., F.R.S., F.G.S., British Museum (Natural History).

THE collecting expedition to the Fayûm in the Spring of 1906 did not result in the discovery of any striking new forms, but nevertheless a large number of specimens was obtained, some of which add considerably to our knowledge of species already imperfectly described. Of these specimens the most important are: (1) An associated skull and mandible of *Palæomastodon wintoni* with the upper and lower dentition, including the tusks, in perfect preservation; an atlas, humerus, radius, part of an ulna, and some vertebræ of the same individual were also found, and confirm the determinations that had previously been made from isolated examples. (2) A beautifully preserved mandible of a very young *Palæomastodon*, probably the same species. In this specimen the two posterior milk-teeth are in position, while the anterior one is represented by its empty alveolus. Beneath the two milk molars are the germs of pm. 3 and pm. 4, almost ready to replace them vertically in the ordinary way. The first molar is in wear, and the crown of the second is fully developed, but had not been cut. One of the most interesting points, however, is that the outer edges of the incisors are serrated, so that this specimen finally proves that the genus *Phiomia* was founded on the anterior portion of a very young mandible of one of the smaller species of *Palæomastodon*, as indeed has already been suggested by Schlosser.[1] The above-mentioned specimens will be described in detail elsewhere. Of the remainder, perhaps the most interesting is a portion of the jaw of the remarkable animal *Geniohyus mirus*, the type-specimen[2] of which is the anterior region of a mandible in which all the cheek-teeth except the talon of m. 3 are well preserved. The most peculiar feature of this specimen was described as being the presence of a downwardly and backwardly directed hook-like process arising from the ventral surface of the ramus immediately behind the symphysis. Another peculiarity noted was the extreme narrowness of the ramus

[1] Neues Jahrb. f. Min., etc., vol. i (1905), pt. 1 (Referate), p. 157.
[2] Geol. Mag., Dec. V, Vol. I (1904), pp. 160–161, Pl. VI, Fig. 4.

beneath the cheek-teeth. It is, however, seen from the present specimen (Fig. 1) that the condition of things was even more remarkable than was supposed, and that the hook-like process was merely the thickened antero-inferior border (*l.b.*) of a large bullate expansion (*foss.*) of very thin (1–2 mm.) bone projecting outwards and forming a large prominence on the postero-inferior portion of the mandibular ramus. Superiorly this is continuous with the outer face of the narrow thickened alveolar part of the ramus; it is convex externally and concave internally. Posteriorly it is strengthened on the inner side by a rounded vertical buttress (*p.b.*) of bone situated about the level of the talon of m. 3. What the function of this inflated expansion of the lower portion of the mandible may have been it is difficult to conjecture. It may possibly have lodged a very large salivary gland or some kind of buccal sac, perhaps connected with the vocal organs. Another peculiarity of this specimen is that behind the

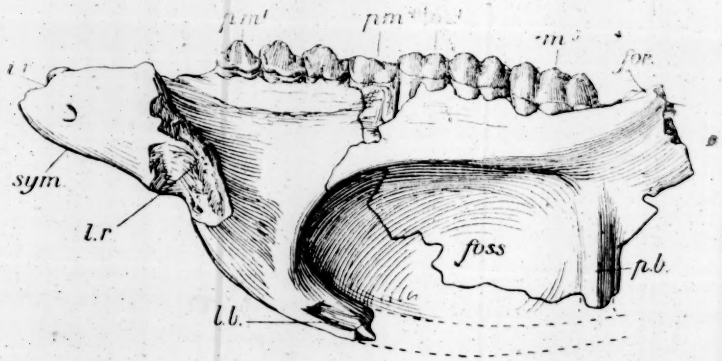


FIG. 1.—*Geniohyus mirus*. Right ramus of mandible from the inner side. The portion of the figure behind the black line is drawn from the new specimen; the anterior portion and the ventral border is from the type-specimen. *for.* line showing the position of the foramen perforating the base of the ascending ramus; *foss.* the inner concave surface of the bullate expansion; *i.* 1, base of first incisor; *l.b.* ventral thickened border of mandible; *l.r.* broken anterior end of the right ramus of the mandible; *m.* 1–3, molars; *p.b.* posterior buttress; *pm.* 1–4, premolars; *sym.* symphysial portion of mandible. ½ nat. size.

last molar there is a foramen that perforates the base of the ascending process and opens on the inner side of the jaw; so far as I am aware, this only occurs in the Hyracoidea, and its presence here suggests the possibility that *Geniohyus* may have some relationship with that group, though from the cheek-teeth alone it would certainly be regarded as not remotely related to the Suidæ. The teeth are well preserved, and agree precisely in structure with those of the type-specimen, though slightly more worn. The talon of m. 3 is complete. It is large and composed of a large main cusp, on the antero-internal side of which is a small accessory tubercle. The valley between the talon and the body of the tooth is partly filled by an accessory tubercle of the postero-external main V.

The dimensions (in centimetres) of the teeth in the new specimen are:

	Length.	Width.
pm. 4	1·2 ...	1·0
m. 1	1·4 ...	1·1
m. 2	1·7 ...	1·3
m. 3	2·4 ...	1·5

A fragment of the left ramus of the mandible with one molar tooth (first or second) seems to belong to the large species of *Geniohyus*, *G. major*, and shows that in that also the peculiar structure of the mandible existed, though whether to the same degree as in *G. mirus* cannot be determined without more material. The dimensions of the molar are: 2·6 cm. long, 1·6 cm. wide. Unfortunately the structure of the skull in this extraordinary animal remains at present quite unknown.

Other specimens of interest are portions of the mandible of *Saghatherium magnum*, one of which consists of the almost complete left ramus (Fig. 2) with the canine premolars and molars well preserved.

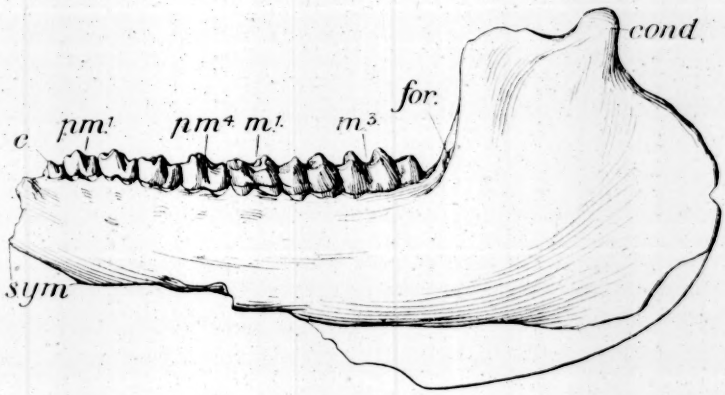


Fig. 2.—*Saghatherium magnum*. Left ramus of mandible, outer side. *c.* canine; *cond.* condyle; *for.* foramen in base of ascending ramus; *m.* 1–3, molars; *pm.* 1–4, premolars; *sym.* symphysis. The lower outline of the angular region is taken from an undistorted specimen. $\frac{2}{3}$ nat. size.

The jaw has been somewhat crushed, in such a way as to diminish its depth beneath the hinder molars and in the region of the angle, the full depth being shown in the second specimen, the outline of which is shown in the figure. On the whole, this mandible agrees very closely with that of the recent Hyracoids. Thus, the perforation (*for.*) of the base of the ascending process just behind the last molar occurs as in *Hyrax*, the angular region is greatly expanded, the posterior portion of the jaw being very deep. The coronoid on the fossil may have been a little less prominent than in the recent forms. The teeth are arranged in a rather strongly curved closed series. The canine which is slightly broken in front is a premolariform tooth, the crown of which consists of a compressed main cusp, with small posterior and probably anterior accessory cusps: this tooth seems to be borne by a single root, somewhat compressed from side to side. The premolars

and molars agree with those already described in the Catalogue of the Fayûm Vertebrates (p. 87).

The total length of the mandible here figured is 13·8 cm., its depth beneath the condyle about 6·5 cm. The lengths of the teeth in millimetres are: canine, 4 app.; pm. 1, 7; pm. 2, 8; pm. 3, 8; pm. 4, 9; m. 1, 10; m. 2, 13; m. 3, 18. The total length of the tooth series (c. to m. 3) is 7·5 cm.; the length of the molar series is 4 cm.

In the other specimen the depth of the ramus beneath m. 3 is 4·3 cm., and the distance from the hinder end of m. 3 to the posterior border of the mandible is about 5·5 cm.

Several more or less imperfect curved front upper incisors of Hyracoids were collected. They were of varying size and are triangular in section, the two anterior faces only being covered with enamel.

The remains of Carnivora are very rare, and few were obtained, the most important being a fragment of the left maxilla, with two teeth (pm. 4 and m. 1). The molar is almost exactly intermediate in form between the corresponding teeth in *Pterodon* and *Hyænodon*, having a less prominent inner tubercle and longer posterior blade than in the former, but in these characters more resembling the latter. It seems, therefore, that this maxilla belonged to *Apterodon macrognathus*, a species founded on a mandible, the dentition of which is likewise in some respects intermediate between that found in the genera above referred to; it also agrees in size with the specimen now under consideration.

An enormous canine, probably that of *Pterodon africanus*, some cervical vertebræ, and a tibia were also obtained.

One rather notable find was the ulna of a large wading bird, apparently nearly allied to *Ardea*. Compared with the same bone of *Ardea goliath*, this ulna is somewhat smaller and notably stouter in proportion to its length, but in the form of its extremities and of the various muscle impressions it is closely similar. Bird bones are extremely rare in these beds, at least in sufficiently good condition to collect.

No notable reptilian remains were found.

It will be seen that very much more remains to be done in the Fayûm, many of the animals described being only very incompletely known, from mere fragments; in several important instances, e.g. *Geniohyus*, the skull remains quite unknown.

II.—Notes on the Rocks of the "Beagle" Collection.

I.

By Alfred Harker, M.A., F.R.S.

THE voyage of the "Beagle" in 1831–6 was not only the starting-point of Charles Darwin's scientific career, but also, and more particularly, it laid the foundation for the whole of his geological work, as embodied in the well-known series of volumes.[1] The

[1] "Journal and Remarks," 1839; 2nd edition, entitled "Journal of Researches . . . during the Voyage of H.M.S. 'Beagle' . . . ," 1845. "The Structure and Distribution of Coral Reefs," 1842. "Geological Observations on the Volcanic Islands . . . ," 1844. "Geological Observations on South America . . . ," 1846.

collections which he gathered during that prolonged voyage of exploration have therefore no small interest of a historical and sentimental kind. It is believed that they possess also a certain intrinsic value; inasmuch as an examination of these original specimens, with the advantages conferred by modern petrographical methods, may sometimes help towards a better understanding of the recorded observations. Owing to his choice of plain language in preference to the now antiquated terminology of his time, Darwin is seldom obscure to a modern reader; but his characterization of the igneous rocks which he observed is necessarily crude and vague. Not a few passages may be considerably elucidated by merely indicating the nature of the rocks which are designated by such old-fashioned comprehensive names as 'porphyry,' 'greenstone,' and 'basalt.' In general, no more than this will be attempted, at least for those islands and districts which have been studied by other geologists with the aid of modern appliances.

The greater part of the "Beagle" collection is now housed in the Sedgwick Museum at Cambridge. It includes some 2,000 rock-specimens, a certain number being lost or missing, and most of the fossils having passed long ago into other hands. Procured often under difficult conditions, carried in many cases long distances overland, and stowed in a confined space on shipboard, the specimens are for the most part not of the size and shape favoured by museum collectors; but they are sufficient to illustrate the rock-masses which they represent, and to provide thin slices for microscopical examination. The original annotated catalogue, occupying four closely written note-books, is a monument of patient labour. Under each number is a condensed description of the rock, as seen by the eye and the lens, besides the necessary records of locality and occurrence. On the opposite page are additional notes, also made during the voyage, giving the results of examination with the blow-pipe, goniometer, magnet, and acid-bottle. Less commonly there are entries made at some later time, sometimes noting an opinion of Henslow or Miller, to whom particular questions had been referred. A copy of this manuscript list is placed with the collection, and it will be referred to as the "Catalogue."

Santiago, Cape Verd Isles.

Although we shall in general omit petrographical details, some exception may be made in the case of rocks which have an interest of their own, and have not become generally known from published descriptions. Such are the lavas of the Cape Verd Isles, which present a considerable range of variety and include some remarkable types. The valuable work of Doelter[1] does not pretend to completeness; and these islands have been so seldom visited by geologists that specimens collected seventy years ago may still furnish interesting material for study.

Both on the outward and on the homeward voyage the "Beagle"

[1] C. Doelter: "Die Vulcane der Capverden und ihre Producte," Graz, 1882. A few rocks collected by Doelter have been described by Fr. Eigel: Tscherm. Min. Petr. Mitth. (2), vol. xi (1889), pp. 91–104. There are also some earlier notes by A. Stelzner: Berg. u. Hütt. Zeit., vol. xxiv, p. 47.

touched at Porto Praya, on the south coast of Santiago,[1] the largest of the Cape Verd group. Darwin utilised his time in exploring the geology of the port and the neighbouring parts of the island, and collected about 150 specimens. We shall refer to the more interesting of these in the order in which they are mentioned in the first chapter of "Volcanic Islands." Of some of them thin slices have been made, and the number of the slides, in the Sedgwick Museum cabinet, will be given in brackets.

The lowest rocks on the coast near Porto Praya and on Quail Island, underlying the white Tertiary limestone, are highly basic, non-felspathic lavas. The fresher specimens show a very dark and compact ground-mass, with crystals of yellow olivine and black augite, which are usually very abundant. Three examples which have been sliced illustrate three different types, and probably represent fairly the whole group. The first [4704] is a *limburgite*. Olivine is the dominant mineral, in perfectly fresh well-shaped crystals. Augite is also abundant, in good crystals with some tendency to stellate grouping. It is very pale in the slice, and often shows fine lamellar twinning. There are also a few little octahedra of magnetite, sometimes enclosed in the olivine. These minerals constitute the greater part of the rock, but there is in addition an abundant glassy base of deep brown colour, enclosing very numerous little rectangular gratings of magnetite.

The second type [4705] shows the same minerals, except that the olivine is largely replaced by serpentine and carbonates. The augite is strongly zoned. The ground-mass consists of a second generation of augite and magnetite, with slender needles of apatite and a clear isotropic base, which is quite colourless. This is evidently an example of the second variety of limburgite distinguished by Doelter (op. cit., pp. 134–137) as having a colourless instead of a brown glass. The true nature of the colourless base is, however, doubtful, and we shall recur to the subject below.

The third type [4706] differs from the foregoing in that olivine is scarcely represented. The phenocrysts are of a pale yellowish-brown augite, zoned and often twinned, with magnetite. The ground-mass consists, as in the last specimen, of abundant little idiomorphic augites, magnetite, many needles of apatite, and a colourless isotropic base, which is here in rather larger amount. This rock evidently belongs to the 'pyroxenites' of Doelter, which Rosenbusch more conveniently terms 'augitites,' the former name being preoccupied by a very different group of rocks. As in the limburgites, Doelter (op. cit., pp. 137–143) distinguishes two kinds, one having a brown glassy base and the other a colourless base, assumed to be also glassy.

The dykes mentioned by Darwin (p. 3) as intersecting these lavas seem to be of related types, but the only one sliced [4713] shows some differences. Augite preponderates over olivine among the porphyritic crystals. The ground-mass, in addition to augite and magnetite, contains little slender crystals of felspar, some with twinning. It is noteworthy that most of these crystals give low

[1] The common English spelling is here adopted. Darwin writes the name 'St. Jago,' and Doelter uses the Portuguese form 'S. Thiago.'

extinction-angles. There is an interstitial base of brown glass. Notwithstanding the presence of some felspar, the affinities of this rock are decidedly with the limburgites rather than the basalts.

The calcareous deposit calls for no remark. The white balls, mostly from one to two inches in diameter, built up by 'Nullipora,' are interesting as the analogue, on a giant scale, of a certain type of oolite. The alteration in the upper part of the calcareous deposit, where it is overlain by the younger lavas ("Volcanic Islands," pp. 5, 6), is probably due to solution and recrystallization at least as much as to metamorphism. Darwin's explanation of the curious intermingling of carbonate of lime and lava here, and again at Red Hill (pp. 10–14), will scarcely be accepted at the present day. He believed "that the lime has been erupted, mingled with the molten lava." His specimens seem to show merely a breccia of pieces of dark lava in a calcareous matrix, and again calcite and aragonite crystallized in the vesicles and interstices of a scoriaceous lava. This is also the opinion which Doelter formed on the spot.

The lavas which overlie the calcareous rocks of the coast district (pp. 9, 10) are, judging by the specimens, poorer in conspicuous phenocrysts than the lower lavas. Usually some small olivines are the only element visible to the naked eye. The compact ground-mass has not the uniformly dark colour of the lower lavas, but is often mottled or streaked with lighter and darker shades of grey. A thin slice of one example [4703] shows small crystals of the usual olivine, pale augite, and magnetite, the olivine being largely replaced by pseudomorphs of a deep red-brown colour. In addition, there are small crystals of felspar with twin lamellation and low extinction-angles. There is finally an abundant isotropic base, quite colourless, enclosing very numerous slender needles of apatite. This colourless base is partly segregated into little patches and streaks relatively free from the crystallized constituents (except apatite), and in these places it shows unmistakably the cubic cleavage characteristic of analcime. The rock may therefore be styled an *analcime-basalt*, allied to monchiquite, the presence of some felspar being the only character distinguishing it from typical monchiquites.

In speaking of the lower lavas, the nature of the colourless isotropic base in the second and third types was left in doubt, its strictly interstitial occurrence making its identification a matter of difficulty. In the rock now considered, although isolation and chemical analysis are desirable to give confirmatory evidence, there can be no reasonable hesitation in recognizing the colourless substance as analcime; nor is there any reason to question its status as a primary constituent of the lava. How far a like interpretation may be applicable to 'limburgites' and 'augitites' with colourless base in the Cape Verd Isles and elsewhere, it would be rash to venture an opinion. If the colourless base in the rocks described above can be regarded as analcime, then [4705] may be named a *monchiquite*, and [4706] a monchiquite without olivine, or, according to the distinction made by J. F. Williams, a *fourchite*.

The lavas of Signal Post Hill[1] ("Volcanic Islands," p. 15) are

[1] 'Flag-staff Hill' in Catalogue; 'Mte. Facho' according to Doelter.

again of monchiquitic affinities. One fresh example has been sliced [4711]. It is a dark-grey rock of compact texture, enclosing abundant olivine, which is partly red from incipient change. Different stages of the process of alteration are shown by other specimens, the final product being the "dark jasper-red earthy mineral," with "indistinct cleavage," described by Darwin in a footnote. It is one of the variable and imperfectly-known alteration products of ferriferous olivine to which iddingsite and several allied substances belong. The slice shows the olivine here to be only slightly altered. As usual in these rocks, its crystals are sharply formed, as are those of the less plentiful augite. The latter mineral is very pale brown, with the zonary banding well marked between crossed nicols and sometimes assuming the hour-glass arrangement. There are also grains of black iron-ore and a few small flakes of biotite. The ground-mass is composed of numerous little crystals of augite and magnetite, with interstitial clear analcime and the usual apatite needles. The rock may be named a *monchiquite*. Another sliced specimen from the neighbourhood of the same hill [4712] is closely similar to the preceding, but the colourless interstitial matter shows some difference. For the most part it is isotropic, and may probably be set down as analcime, though the cleavage is not so evident as in the other slice. There are, however, patches, not distinguishable from the rest in natural light, which are birefringent, and are probably nepheline. It may be recalled that this mineral is found occasionally in the original monchiquites of Brazil.

The "inland hills of more ancient volcanic rocks" have not furnished many specimens to Darwin's collection, and none of these have been sliced. Fresh examples from the "upper strata" are dark compact rocks enclosing abundant little grains of olivine, and they may be allied generally to the limburgites and monchiquites, though in one case a few slender crystals of felspar are just discernible. The specimens from the "basal strata" are not fresh enough to be diagnosed, and are of close texture without visible crystals. They have a yellowish-white colour, with ferruginous staining, and it is possible that they are, as Darwin supposed, of trachytic nature, though Doelter found no true trachytes in the Cape Verd Isles.

Several specimens are described in the Catalogue as "various crystalline rocks forming more central part of island," and are stated to come from north-west of Porto Praya, without closer specification. They evidently belong to the same group of lavas as those found in the coast district, and may be from some of the same flows. One example sliced [4707] is a *limburgite* like the one described above from Quail Island [4704], except that the brown glass is here more abundant than in the former case, and encloses only a few minute crystals of magnetite instead of the abundant skeleton growths. Another specimen [4708] is not very different. The porphyritic elements are the same as before, except that the olivine is now replaced by carbonates. In the ground-mass, besides the little crystals of augite, there are others of felspar, giving moderate extinction-angles, and the interstitial base is the usual deep brown glass of the limburgites.

A specimen from the precipice surrounding the village of S. Domingo ("Volcanic Islands," footnote on p. 20) shows the usual abundant crystals of olivine set in a dark compact ground-mass, but a thin slice [4714] brings out certain differences. The olivine crystals are transformed, marginally or sometimes totally, into a deep red-brown mineral, having a high birefringence comparable with that of the olivine but with oblique extinction. There are also a few small flakes of biotite in the rock. The general ground-mass shows abundant minute crystals of augite, with some of magnetite, in a colourless base, enclosing very abundant needles of apatite. The base is in part isotropic, doubtless analcime, but largely of a birefringent mineral, which seems to be felspar rather than nepheline. Much of it has the appearance of sanidine. In places, however, the interstitial material has segregated out into relatively large clear patches, and these consist partly of analcime, partly of a lamellated plagioclase with low extinction-angles.

It appears from the foregoing notes that the prevalent types of lavas in the southern part of this island are of highly basic or ultra-basic composition, and belong principally to the limburgite-monchiquite group, though including some aberrant varieties. There remain to be noticed the phonolites, which may perhaps be regarded as the leucocratic complements of the preceding. Darwin remarks that, among the trachytic-looking rocks which make the lower parts of the flat-topped hills inland from Porto Praya he found in three places "smooth conical hills of phonolite, abounding with fine crystals of glassy felspar, and with needles of hornblende" ("Volcanic Islands," pp. 19, 20). In the Catalogue two of the specimens are described as from 'paps' peeping up among the "various crystalline rocks" (limburgites, as we have seen) north-west of Porto Praya, and the third from "pap-like hills composed of vitreous felspar" north-east of Porto Praya. Darwin's account seems to imply, though not very clearly, that their relations are intrusive, but Doelter terms these little hills 'Kuppen.' The specimens show fresh crystals of sanidine, up to ½ inch in length, in a compact ground-mass of lighter or darker shades of grey, with the characteristic lustre imparted by abundant nepheline. While belonging to the *phonolite* family, they exhibit considerable variety of characters. The three specimens sliced illustrate as many different types, and they differ also from one described by Doelter[1] from the same neighbourhood.

In the first type of phonolite [4710] the porphyritic elements are sanidine and ægirine, with some crystals apparently of altered nepheline and a few octahedra of magnetite. The ægirine is green, with fairly marked pleochroism, and much of it occurs as aggregates of little crystals making pseudomorphs after larger crystals. The ground-mass, constituting the greater part of the rock, is composed of very abundant little crystals of nepheline with sanidine.

In the second type, [4709] the porphyritic elements are more abundant, and include a greater variety of minerals. In addition to the large sanidines there are well-shaped crystals of nepheline, fairly

[1] Op. cit., pp. 88–91, with chemical analyses. The word 'nephelinarmen' at the beginning of the description should be 'nephelinreichen.'

numerous little dodecahedra of sodalite, turbid in the interior, abundant green pyroxene and deep brown melanite, and some rather irregularly-shaped crystals of pale sphene. The pyroxene is an ægirine-augite with strong pleochroism in bluer and yellower shades of green. The extinction-angle in vertical sections scarcely exceeds a value of about 30°. In one clinopinacoidal section the main part of the crystal gives 32°, while a border of rather deeper colour gives 27°. The ground-mass of the rock, with well-pronounced flow structure, is composed of sanidine, nepheline, and a pyroxene, apparently ægirine, while slender needles of apatite are seen in places.

The third type of phonolite [4715] differs from that last described in carrying hornblende. The sanidine, nepheline, sodalite, ægirine-augite, and melanite are present as before, and the ground-mass is of nepheline, sanidine, and ægirine, with fluxion-structure. The hornblende crystals are idiomorphic, usually twinned, and in colour from brownish-green to greenish-brown in the thin slice. They have been corroded by magmatic resorption, the product of this reaction being green ægirine-augite, which mineral also occurs separately in small idiomorphic crystals. It appears probable that the aggregates of ægirine crystals noted in the first type [4710] have likewise been formed at the expense of hornblende, the transformation in that case being complete. It may further be enquired how far the seemingly independent crystals of pyroxene in these rocks may be due to the breaking-up of such aggregates, which originated as resorption-pseudomorphs after hornblende.[1] If there be any truth in this suggestion, Doelter's distinction between augite-phonolites and hornblende-phonolites may perhaps mark no very essential difference. It is noteworthy that, in the phonolite from this neighbourhood which he studied, the two generations of pyroxene were found to differ greatly in composition, the one being an augite containing but little soda, and the other apparently an acmite or ægirine with a remarkable content of manganese.

The tephrites, basanites, felspar-basalts, and nepheline-basalts recorded by Doelter from various parts of the island of Santiago do not seem to be represented in the "Beagle" collection, so far as can be judged from megascopic characters; and the prevalent types in the district of Porto Praya are doubtless fairly illustrated by the specimens which we have selected for examination.

III.—The Relation of the Concretionary Nodules of the Yarra to the Calcareous Nodules known as 'Coal-Balls.'

By M. C. Stopes, Ph.D., D.Sc., Lecturer at Manchester University.

SPHEROIDAL concretions from the Yarra estuary which were found to contain plant-remains were described by Mr. Chapman recently in this journal.[2] The structures in themselves are of

[1] A like question has been raised by Washington with reference to the augite-grains in many hornblende-andesites: Journ. Geol., vol. iv (1896), pp. 273–278.

[2] F. Chapman, "On Concretionary Nodules with Plant-Remains found in the Old Bed of the Yarra at S. Melbourne: and their Resemblance to the Calcareous Nodules known as 'Coal-Balls'": Geol. Mag., December, 1906, p. 553.

considerable interest to geologists, and also to palæobotanists from the fact that they contain "matted fragments of woody and foliaceous material." They were made the subject of some comparisons with the calcareous concretions from the Lancashire Coal-measures, and as a result certain general considerations were brought forward, which call for comment, and which are of sufficient importance to receive attention.

In the first place, the comparison which Mr. Chapman made between the Yarra concretions and the English 'coal-balls' is hardly justified by the facts when they are carefully considered. By those who have a practical acquaintance with the English Coal-measures the 'coal-balls' or calcareous concretions which are found actually *in* the coal itself are at once recognised as being very different in their nature, formation, and occurrence from the clay ironstone or clay nodules which are found widely distributed in the various beds of the Carboniferous, and which also contain fragments of plants in many cases. Yet, though it is with the latter that the Yarra concretions more nearly approximate, it is to the former that Mr. Chapman has compared them. Nevertheless, he calls them 'clay nodules,' and describes the clayey nature of their outer layers, and states that under microscopic examination the matrix "was seen to consist of quartz-grains, fine calcareous and argillaceous particles, brown woody tissue, and valves of the marine diatom *Actinocyclus*." Further, the residue from the nodule was shown, after treatment with H Cl, to consist of "a fine angular quartz sand, the grains of which have a diameter varying generally between ·1 mm. and ·018 mm. Some tourmaline and zircon crystals were also present." None of which things, to my knowledge (except the woody tissue and the calcareous matter), are in the least characteristic of the true 'coal-balls,' which are singularly free from such materials. Of the coal-balls I have examined many hundreds, both *in situ* and in the laboratory, and have also followed the results of the many analyses which have been done for the special work I have been undertaking.

Mr. Chapman continues:—"From the occurrence of the nodules on the sides of the old river channel, and seated in depressions, we may reasonably assume that they received their form in 'kettles' or 'potholes' in the clay bottom of the river bed." These facts, again, are fundamentally opposed to those that hold for the Yorkshire and Lancashire 'coal-balls,' which occur neither in old river channels nor in 'kettle' depressions, but are found in a normal seam replacing the coal in local patches, in which the stratification of the coal round them is regular and undisturbed, and shows none of the 'swirling eddies' suggested by Mr. Chapman for the cause of the rounded form of these concretions. When Mr. Chapman enters into the theory of their mode of formation he reveals that he is seriously hampered in this attempt by want of facts and an intimate knowledge of the actual details of the case of the Lancashire and Yorkshire 'coal-balls.'

Though superficially the Yarra concretions and those of the English coal-seams may appear to be similar structures, yet I think that enough has been said to show that they are of fundamentally different construction and mode of origin.

The Yarra concretions being formed as they are of clayey masses surrounding fragments of plants are, however, directly comparable with the clay concretions and clay ironstones which are constantly found in the English Coal-measure beds, and which have also yielded many valuable specimens of fossil vegetables. These, however, are in no way comparable with the true 'coal-balls,' which are a formation as unique and as characteristic as any structure in the range of geology.

That it is "worth a further enquiry" into the theories of formation of the English coal-balls, is a conclusion with which one can heartily agree with Mr. Chapman, even while controverting his original premises, and I may add that during the last few years, assisted by the Royal Society and in conjunction with Mr. Watson, I have been undertaking work of an extensive and detailed nature on the subject. The results of this work all point to the truth of the *in situ* theory for the coals in which the true 'coal-balls' are found, and in a full paper we hope to set forth the many and various facts which support this statement. It must not be forgotten, however, that the coals in which these structures occur are in many ways rather special cases, and show certain characters which are almost unique, so that "the evidence already known, which goes to prove an allochthonous origin for much of the coal-deposits of various ages in different parts of the world," does not affect the question. Geology is now sufficiently advanced to recognise that there may be two or more modes of formation for the various coal-seams. When structures so characteristic and so unique as the true calcareous 'coal-balls' occur in a seam, it is but natural to be prepared to find that some rather unusual conditions were associated with the deposition of that coal.

To conclude. It appears that in the facts of importance in their structure and origin the Yarra nodules do not resemble the calcareous nodules known as 'coal-balls,' and that therefore conclusions as to the origin and occurrence of the latter based on a comparison with the former must inevitably be fallacious. The Yarra concretions are none the less interesting, and may be compared with other concretionary structures in the Carboniferous with great advantage.

IV.—Sedgwick Museum Notes.

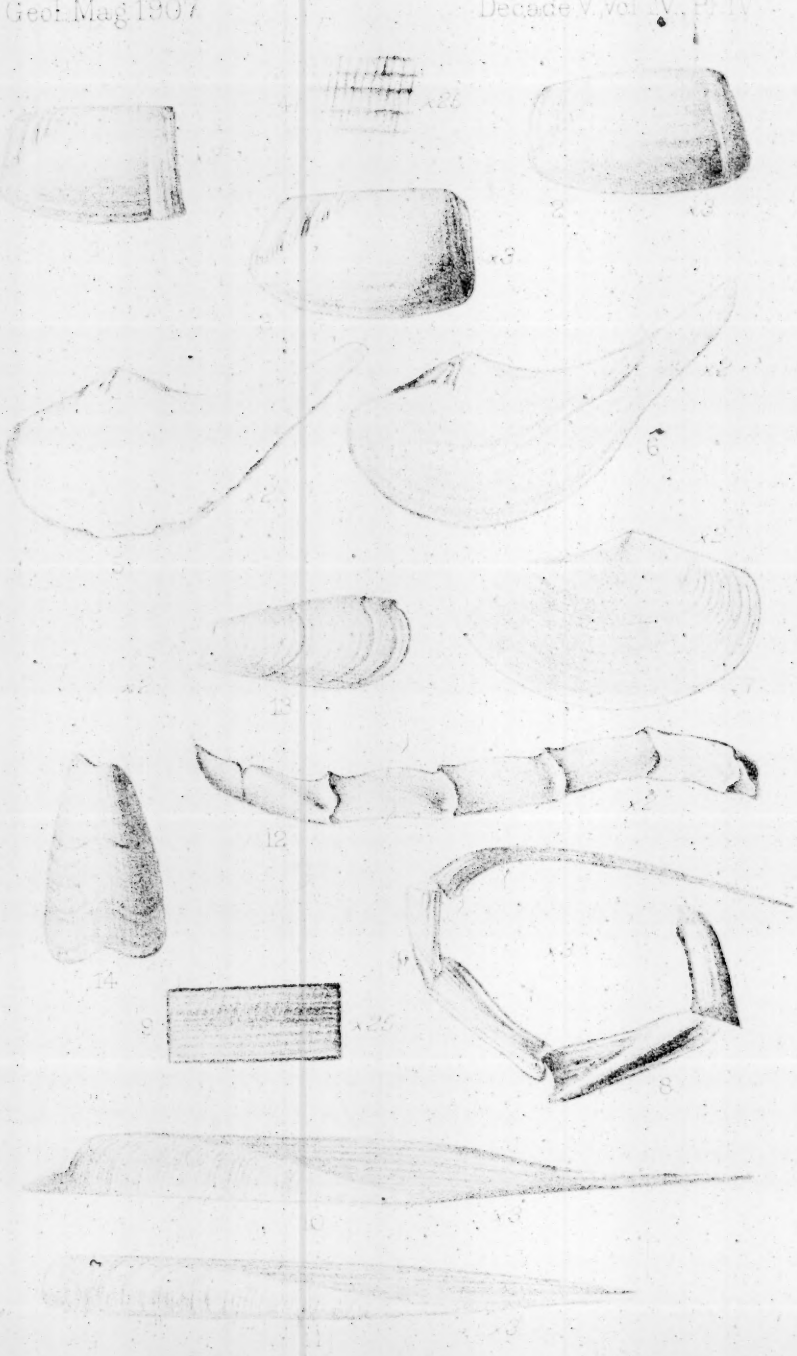
Crustacea, etc., from Girvan.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE IV.)

THE numerous and full accounts of the Crustacea (apart from trilobites) from the Girvan area which Professor Rupert Jones, Dr. H. Woodward, Mr. R. Etheridge, jun., and others[1] have published during the last three or four decades may seem to render any further remarks by me superfluous. But at Dr. Henry Woodward's suggestion Mrs. Gray recently sent to me some fresh material for examination, which, in addition to yielding some new species, throws some interesting

[1] Peach: Proc. Roy. Phys. Soc. Edinburgh, vol. xiv (1902), Session 1900–1901, Pres. Add., p. 369.



Crustacea &c from Girvan

light upon previously described forms, and permits some further details to be added to our knowledge of them.

ANATIFOPSIS BALCLATCHIENSIS, sp. nov. (Pl. IV, Figs. 1–4.)

Diagnosis.—Valves oblong, about 1½ times as long as high, longer along ventral than dorsal margin, narrower in front than behind, transversely gently convex (in a dorso-ventral direction). Dorsal margin nearly straight or gently arched. Anterior end narrowed slightly, obliquely truncated in front, obtusely pointed below. Ventral margin decidedly convex, longer than dorsal. Posterior end straight, truncated abruptly and nearly at right angles to dorsal edge, with narrow marginal raised rim, and a fairly strong narrow straight groove parallel to margin and at a short distance from it, followed behind by a few finer parallel impressed striæ. From the inferior angle of the anterior end, a rather strongly impressed straight diagonal line traverses the valve, meeting the dorsal edge a little in front of its middle length and thus cutting off a triangular area on the surface. Below and behind this impressed line the surface is ornamented with longitudinal raised lines or fine lamellæ, parallel to the ventral margin; these lamellæ, on crossing the diagonal line, bend up suddenly to run parallel to the anterior end of the valve, and at the same time increase somewhat in strength. A delicate transverse lineation at right angles to the longitudinal lines and between them is visible in well-preserved specimens.

Dimensions:

	I.	II.
Length	8·0	9·5 mm.
Height (at posterior end) ...	5·0	6·0 mm.

Horizon and Locality.—Balclatchie Beds, Balclatchie, Girvan.

Remarks.—In 1895 Professor Rupert Jones and Dr. Henry Woodward[1] briefly described and figured an imperfect fossil from Balclatchie, which they doubtfully referred to the lamellibranch genus *Cypricardinia*, remarking at the same time that in one position it had somewhat the appearance of a broken portion of a *Pinnocaris*. Mrs. Gray has recently submitted to me this specimen and over a dozen more, some of which are much better preserved than the type. On further investigation of these fossils and comparison with Barrande's *Anatifopsis bohemica*[2] of Etage *Dd* 3–*d* 5, I am convinced that they must be referred to this genus, whatever its true position amongst the Crustacea may be. Our specimens bear a very close resemblance to the one figured by Barrande in fig. 36, pl. xxvi (*op. cit.*), and possess all the essential characters of the genus. It is interesting to observe that Barrande himself stated that Wyville Thomson had discovered a fossil similar to *Anatifopsis* in the South of Scotland.

Nearly all our specimens are of left valves, as Barrande also remarks is the case in *A. bohemica*.

The peculiar transverse grooves or grooves at the posterior end of the valve are interpreted by Barrande as thoracic segments; but if so,

[1] Jones & Woodward: GEOL. MAG., Dec. IV, Vol. II (1895), p. 542, Pl. XV, Figs. 4*a*, 4*b*.

[2] Barrande: Syst. Silur. Bohême, vol. i, suppl. (1872), p. 578, pl. xxvi, figs. 36–41.

they are completely fused with the cephalic shield, and the presence of free segments behind is conjectural. Indeed, the genus has been placed by some palæontologists amongst the Cirripedes, and it is possible that it is really allied to *Lepas*. The dorsal edge of the valves is never well seen, but is more incurved than the ventral.

There is a somewhat longer and narrower form of valve represented at Balclatchie, with the dorsal and ventral margins straighter and nearly parallel, but otherwise possessing precisely the same characters as the above, so far as can be seen in the two imperfect examples before me. It probably belongs to another species, and bears much resemblance to the insufficiently known *A. longa*, Barrande (op. cit., p. 579, pl. xxvi, figs. 42–45).

PINNOCARIS CURVATA, sp. nov. (Pl. IV, Figs. 5–7.)

The single species of this peculiar genus hitherto known was first described[1] by R. Etheridge, jun., from the Balclatchie Beds of the Girvan district, but was subsequently treated more fully by the same author in conjunction with Professor Nicholson in their "Monograph on the Silurian Fossils of Girvan," vol. i, 1880, pp. 207–210, pl. xiv, figs. 17–20. Since then Professor Rupert Jones and Dr. Henry Woodward have discussed it on two occasions[2] and published figures and accounts of the Balclatchie specimens in Mrs. Gray's collection, and of one English example from the Upper Silurian of Kendal.

There are seven specimens of a member of this genus, from the Starfish Bed, Drummuck Group, of Thraive Glen, which Mrs. Gray has sent me for examination. The horizon is new, and the characters of the fossil are such as to warrant its specific separation from the Balclatchie form which was named *P. Lapworthi*. The name *curvata* may be proposed for it on account of its peculiar shape.

Diagnosis.—Carapace bivalved. Valves flattened, triangularly obovate and elongate, posteriorly curved upwards; anteriorly broad, widening to middle of valve, then tapering rapidly into long narrow produced posterior portion. Pseudo-umbo situated at about one-third the length of the shell from anterior end. Dorsal margin in front of pseudo-umbo obliquely inclined downwards, slightly concave, thickened internally; margin behind pseudo-umbo curved, markedly concave upwards. Anterior margin short, regularly rounded, semi-elliptical. Ventral margin strongly convex to a little behind middle of valve, then curving rapidly upwards and slightly concave. Posterior portion of valve narrow, elongate, tapering to blunt end, gently convex, not corded, but marked with weak submedian groove along its length. Surface of valves marked with regular striations concentric to ventral margin, centreing on pseudo-umbo, and ending abruptly against pre-umbonal dorsal margin. In internal casts there is in each valve a short slit proceeding obliquely forwards from the umbo at a small angle to the margin, and immediately in front of it is another but

[1] R. Etheridge, jun.: Proc. Roy. Phil. Soc. Edinb., vol. iv (1878), p. 167, pl. ii, figs. 3–5.

[2] Jones & Woodward: Mon. Brit. Palæoz. Phyllocarida (Palæont. Soc.), pt. ii (1892), pp. 118, 119, pl. xv, fig. 24; id., GEOL. MAG., Dec. IV, Vol. II (1895), pp. 542–545, Pl. XV, Figs. 5–10.

weaker slit, or rather groove, making a smaller angle with the margin. These slits represent short ridges in the interior of the valves.

Dimensions:

	A.	B.	C.
Length	30·5	26·0 ...	15·50 mm.
Width	13·0	12·0 ...	6·25 mm.

Remarks.—This species differs from *P. Lapworthi* in the curved form of the shell, the posterior part being strongly bent up, and the dorsal margin concave instead of straight and apparently not corded. The anterior end is also narrower, and the posterior portion relatively shorter. The pre-umbonal ridges are a special feature, and suggest doubts as to the reference of this fossil to the Crustacea. One of our specimens (c) shows both valves of the carapace on counterpart slabs of rock, and from it we are able to see that the posterior elongation of the shell forms by the juxtaposition of the two valves a narrow laterally compressed tube.

PINNOCARIS LAPWORTHI, Etheridge, jun.

In addition to some excellently preserved examples of this species in the Sedgwick Museum from the type locality Balclatchie, Mrs. Gray's collection contains some from the same beds at Dow Hill and Ardmillan; and another specimen from the higher beds of Shalloch Mill is scarcely to be distinguished from this species, but its state of preservation makes its determination a little uncertain.

DIPTEROCARIS (?) sp.

There is one imperfect right valve from Ardmillan in Mrs. Gray's collection which appears to be identical with the form from Penwhapple Glen which was described and figured by Messrs. Nicholson and Etheridge[1] as *Peltocaris* sp., but which Professor Rupert Jones and Dr. Woodward[2] believe may belong to the American genus *Dipterocaris*, Clarke. Apart from the new locality and horizon there is nothing further to learn from our specimen.

SOLENOCARIS SOLENOIDES, Young. (Pl. IV, Figs. 8, 9.)

The fossil described in 1868 by Messrs. Young[3] as *Solenocaris solenoides* was referred by Professor Rupert Jones and Dr. Henry Woodward[4] in 1885 to the genus *Helminthochiton*. The specimens figured by these authors, together with some fresh material from the same locality, Balclatchie, have been submitted to me by Mrs. Gray, and a recently acquired specimen in the Sedgwick Museum has also been examined. There would be nothing further to add to the description of the species already published if it were not for the presence of one important specimen in Mrs. Gray's collection, which shows four consecutive segments of the body (and a trace of a fifth) possessing the typical characters (see Woodward's figure, op. cit., pl. ix, fig. 11), but which are followed by a long styliform appendage

[1] Nicholson & Etheridge: op. cit., p. 212, pl. xiv, fig. 2.

[2] Jones & Woodward: Mon. Brit. Palæoz. Phyllopoda, p. 112, footnote.

[3] Young: Proc. Nat. Hist. Glasgow, vol. i (1868), pt. 1, pp. 171–173, pl. i, figs. 7*a*, *b*.

[4] Jones & Woodward: GEOL. MAG., Dec. III, Vol. II (1885), p. 336, Pl. IX, Fig. 11.

recalling the caudal style of *Ceratiocaris*. The four segments and the style seem to belong to one and the same individual, and are curved round into a rough circle so that the style overlaps and crosses the first of the segments. The style has been slightly displaced, but seems to articulate with the last segment, though it is placed at what Messrs. Young considered the anterior end of the plate. It has the usual elongate slender triangular shape of a caudal style of *Ceratiocaris*, and tapers gradually to a point, though the latter is hidden by matrix. In length it is at least three times that of the last segment; it is slightly curved at the base, which is rounded, truncate, and slightly swollen, and the surface is longitudinally striated and very minutely granulated, the granules being arranged in transverse linear series, giving the appearance of fine transverse striation. Young mentions a similar fine granular ornamentation on the plate of the type-specimen of *Sol. solenoides*.

There are also in Mrs. Gray's collection two elongated segments of probably the same species, but from Dow Hill and Ardmillan respectively; they are much longer and narrower in proportion than the Balclatchie segments, one measuring 10·25 mm. long by 2 mm. wide at the anterior end, and the other 9 mm. by 1·75 mm.; they decrease slightly in width posteriorly, otherwise they agree in characters and ornamentation with the typical examples from Balclatchie.

In the face of this new evidence it may be well to hesitate to refer this fossil to the genus *Helminthochiton*; and with the suspicion that it may ultimately have to find its place amongst the Phyllocarida we may return to the old generic name *Solenocaris*[1] without committing ourselves to any final decision on its affinities.

The main points of distinction between the Balclatchie form *S. solenoides*, and the one from the Upper Bala beds of Penwhapple Glen and Thraive Glen known as *Helminthochiton Grayiæ* have been pointed out by Professor R. Jones and Dr. Woodward, and need not be here repeated. But it may be added that in *Sol. solenoides* the longitudinal ridges below the diagonal ridge are parallel and straight, and meet the diagonal at a very acute angle, whereas in *H. Grayiæ* they curve up to meet the diagonal at nearly a right angle. The plates of the former also are covered with a shining black chitinous substance, as is the case with Crustacea from the same bed, whereas this covering is absent from the plates of *H. Grayiæ*, and they seem to be composed of a calcareous material, and are altogether thicker and stouter in substance.

Dimensions of figured specimen showing four segments and style:—

Length of segments	7·0–5·5 mm.
Height of ditto	3·0–2·5 mm.
Length of style	+14·5 mm.
Estimated total length of ditto	18·0 mm.
Width of spine at base	2·0 mm.

CERATIOCARIS (SOLENOCARIS?) sp. (Pl. IV, Figs. 10, 11.)

There are several specimens from Balclatchie in the Sedgwick Museum similar to the style-like body accompanying a specimen of

[1] Nicholson & Etheridge: Mon. Silur. Foss. Girvan, fasc. i (1878), p. 207.

Pinnocaris Lapworthi figured by Jones & Woodward.[1] When only the broader part is preserved they resemble *Hyolithes*, but it is found that the apex is prolonged into a slender spine of greater or less length in complete specimens; and they possess a black shining chitinous (?) shell like *Solenocaris solenoides*. In Mrs. Gray's collection there is one from Dow Hill measuring 34 mm. long and 3 mm. wide at its base, and another measuring a little over 30 mm. long. The flattened broader part, which is equal to about half the length of the whole style, tapers very slightly, has a rounded or truncate base, and is marked with a faint diagonal ridge, above which are weak longitudinal ridges or striæ, and below which are fine regular transverse striæ curving forwards a little to meet the diagonal. The spine is slender and rounded, and scarcely tapers at all from its base. Occasionally the whole basal portion of the style is crossed by the transverse striæ, and the diagonal and longitudinal lines seem absent; and probably we here see the inferior face of the spine, if it was triangular in cross section.

Helminthochiton Grayle, H. Woodward. (Pl. IV, Fig. 12.)

The species was minutely described on the evidence of two pieces of the same individual, and its affinities were discussed by Dr. Henry Woodward in 1885.[2] Further specimens, numbering thirteen in all, from the same locality, Thraive Glen, have been recently sent to me for examination by Mrs. Gray: ten of these are marked as coming from the Starfish Bed; four of them consist of internal casts and external impressions of two nearly perfect (?) individuals, one being as complete as the type, consisting of seven plates; and the other, though broken, showing the impression of six segments. In another impression of the outer surface from Thraive Glen there are seven plates distinctly present, though the terminal portions of the two end plates of the series are broken. Two other specimens from the Starfish Bed, each with one end imperfect, show only six plates. The other specimens are more fragmentary, or consist of fewer plates. However, from the evidence of the one from Thraive Glen we may conclude that there were at least seven segments in the organism, and we cannot feel certain that there may not have been several more. The specimen here figured from the Starfish Bed with six distinct segments has traces of a seventh at the larger (anterior ?) end, which is bent sharply down into the matrix: the other (posterior) end is narrower and slightly curved upwards, and the sharp dorsal ridge is produced into a distinct terminal short spine, the posterior margin of the plate not being abruptly truncated nearly at right angles (as in the others) but sloping up obliquely to meet the spiniform prolongation of the dorsal ridge at an angle of about 30°. In all the plates there seems to be a short pointed process at the posterior end of the dorsal ridge, overlapping the succeeding plate.

In two of the specimens from Thraive Glen the shell is preserved, and there seems to be on these plates, as in the external impressions

[1] Jones & Woodward: Geol. Mag., Dec. IV, Vol. II (1895), p. 544, Pl. XV, Fig. 5*a*.

[2] Woodward: Geol. Mag., Dec. III, Vol. II (1885), p. 352, Pl. IX, Figs. 7–10.

from the Starfish Bed, a minute linear granular ornamentation on the ridges parallel to the inferior border.

The anterior, shorter, more rounded plate, which Dr. Woodward describes in the type as probably the cephalic plate, does not seem to be preserved in any of the new specimens. Our figured specimen, which measures just 40 mm. when we straighten out its curved body, has the first perfect plate at the anterior end measuring 8·5 mm. in length; the succeeding three are of nearly the same length, but the fifth one is only 5·5 mm. long, and the terminal one only 4 mm. The height of the plates decreases gradually from about 5 mm. at the anterior end to 2 mm. at the caudal extremity. The ornamentation, having been carefully figured and described by Dr. Woodward, calls for no further remarks. Unfortunately the new material does not throw any fresh light on the affinities of the fossil, but the discovery of a long caudal style in *Solenocaris subnuides*, which in so many respects resembles *H. Grayiæ*, makes us feel somewhat less certain about its true zoological position.

CHITON sp. (Pl. IV, Figs. 13, 14.)

There is one specimen in Mrs. Gray's collection from the Saugh Hill Group of Woodland Point, Girvan, which must be referred to the genus *Chiton*, and in some respects bears a resemblance to the only Silurian species which has been described, *Ch. grayanus*, De Koninck.[1] Our specimen consists of two consecutive segments in contact, the whole forming a conical body about 17 mm. long, tapering anteriorly at an angle of about 20° to a pointed end; it is strongly convex, but not dorsally keeled, the plates being arched down regularly on each side from the rounded dorsum. The anterior plate (broken in front) is of an acutely triangular shape, measuring about 9 mm. in length, 4 mm. in height, and 6·75 mm. in width at the base; the posterior margin has a sinuous outline, being excavated in the centre, curved back at the sides to form the apophyses, and then sharply curved forwards to the inferior margin. The second plate is transversely subrhomboidal, and at first seems to consist of two fused plates, owing to a deep groove across it behind its middle which is due to a suspension of growth, as De Koninck described and figured in *Ch. grayanus*. It measures about 7·5 mm. in length, 5 mm. in height, and 8·75 mm. in basal width. Its posterior margin has the same sinuous outline as its anterior edge.

Each plate has the shell preserved, except near the point of the anterior segment, and shows concentric growth-striæ parallel to the sinuous margin, with some faint diagonal striæ on the sides radiating from the front end of the first segment and crossing both segments impartially; there also appears to be a fine granulation present.

The nearest ally of this form is certainly *Ch. grayanus*, but the pointed anterior plate is quite different to the subcircular one conjectured by De Koninck for the latter.

From the Middle Bala of Shalloch Mill Mrs. Gray has obtained one

[1] De Koninck: Bull. Acad. Roy. Sc. Belgique, ser. II, vol. iii (1857), pp. 190–199, pl. i; transl. W. H. Baily, Ann. & Mag. Nat. Hist., ser. III, vol. vi (1860), p. 96, pl. ii, figs. 1*a–d*.

isolated imperfect plate of a *Chiton*, in which the sides are bent down rather more acutely and suddenly leaving a narrower dorsum, but the ornamentation and general shape appear to be indistinguishable from the Llandovery form above described.

EXPLANATION OF PLATE IV.

FIG. 1.—*Anatifopsis balclatchiensis*, sp. nov. Left valve. × 3. Balclatchie Beds: Balclatchie.
,, 2.—Ditto. Ditto. × 3. Same horizon and locality.
,, 3.—Ditto. Ditto. × 3. Same horizon and locality.
,, 4.—Ditto. Ornamentation of surface. × 25.
,, 5.—*Pseudocaris curvata*, sp. nov. Left valve. × 2. Starfish Bed: Drummuck Group, Thraive Glen.
,, 6.—Ditto. Ditto. × 2. Same horizon and locality.
,, 7.—Ditto. Anterior portion of right valve, showing ornamentation. × 2. Same horizon and locality.
,, 8.—*Solenocaris solenoides*, Young. Posterior four segments with caudal spine attached. × 3. Balclatchie Beds: Balclatchie.
,, 9.—Ditto. Ornamentation of surface of spine of same specimen. × 25.
,, 10.—*Ceratocaris* (*Solenocaris*?) sp. Caudal spine. × 3. Balclatchie Beds: Dow Hill.
,, 11.—Ditto. Ditto. × 3. Same horizon and locality.
,, 12.—*Helminthochiton Grayiæ*, H. Woodward. Internal cast of portion of body, showing the seven posterior segments. × 2. Starfish Bed: Drummuck Group, Thraive Glen.
,, 13.—*Chiton* sp. Side view. × 2. Saugh Hill Group, Woodland Point.
,, 14.—Ditto. Same specimen, top view. × 2.

V.—Deformation and Variation in the Sea-Level.[1]

By H. W. Pearson.

CHANGES in the relative level of sea and land along the oceanic borders of the globe seem to have been in continual progress during the entire historic period. Too slow and gradual for direct observation, they can only be detected through comparison of ancient with modern maps, records, or statements. This comparison has now, in hundreds of cases, been made, and it is well established that stability of coastline is the exception, movement of elevation or depression the rule. In one region, it has been observed, the sea for long periods of time has been in continual retreat; at another location it has been long advancing over the land, while at some third point it seems to have remained fixed in position.

In the days of Linnæus and Celsius, when the uplift of the Baltic shores was first recognized, it was believed that this motion could be best explained by assuming an actual depression, or falling, in the surface of the sea, but since the time of Playfair this idea has been entirely abandoned, and all authorities now hold that these motions must be due to movement in the crust of the earth.

Playfair's law, which has thus remained in possession of the field, has recently been restated by Professor Fairchild in the 5th edition of Leconte's "Elements of Geology" (p. 145), as follows:—"But by the principle of hydrostatic level, it is clearly impossible that the ocean should rise or fall *permanently* at one place without

[1] For former paper, see Geol. Mag., 1901, pp. 167, 223, and 253.

being similarly affected everywhere. It is certain, therefore, that the changes we have described above, being in different directions in different places, must be due to movements of the solid crust."

It seems that the conclusion above reached, based upon an argument first advanced about a century since, yet remains unchallenged. The position assumed, at first glance, appears logical, plausible, and unassailable. Nevertheless, there are certain considerations arising from facts of recent development that should induce us to examine this problem anew.

It will be seen that the entire weight of the above-mentioned argument is contained in the assumption—"It is absurd to assume a rise of the sea-level in one place and a fall in another at the same time" (Huxley, Physiography, p. 211); and if we find this position to be in error the long-adopted principle of Playfair must be held no longer tenable.

In opening this question anew, let us first give consideration to Mr. William Ferrel's law of deformation of sea-levels by ocean currents, contained in *Science*, vol. vii, p. 76. In this paper it is shown that oceanic currents impinging upon a shore-line have a tendency to *elevate*, those flowing away from a shore-line have a tendency to *depress*, the surface-level of the adjoining waters. A table is also given by which the amount of this deformation in any given latitude may be determined when the rate and direction of flow are known. By application of this table, and with the most conservative estimate that the Gulf Stream is flowing poleward at the rate of but four miles in twenty-four hours, Ferrel shows that the waters adjoining New York would be depressed about 5 feet below, and the waters adjoining Liverpool elevated 5 feet above, the normal sea-level, through the disturbing effect of the waters' flow. This total difference of 10 feet in elevation, however, he estimates will be cut down about one-half from the effects of under-currents impelled by the differing hydraulic heads above mentioned. His net result, therefore, is to find the waters around France and the British Islands elevated some $2\frac{1}{2}$ feet above, and those around New York depressed some $2\frac{1}{2}$ feet below, the normal level of the sea.

The values above reached, however, seem much smaller than the actual current velocities will warrant. Data from the papers and charts of the U.S. Hydrographic Office and the English Admiralty give results at least double or treble the value of four miles in twenty-four hours assumed by Ferrel. We must consequently conclude the waters adjacent to the British Isles to be elevated some 5 to 7 feet above the normal oceanic surface.

To the north of England the current is compelled to a more northerly course. This change in direction, combined with the effect from the more rapid shortening of the cosines of these latitudes, seems to make necessary on the coast of Norway a still greater rise in surface elevation than has already been determined for the coasts of England.

This writer, with data somewhat uncertain both as to direction and velocity, has reached results off the north coast of Norway calling for an elevation of over 20 feet in the surface-waters on these shores.

This amount, if reduced one-half by escaping currents as estimated by Ferrel, would still leave deformation of over 10 feet.

Applying in similar manner Ferrel's law to other ocean currents, we find deformation in sea-level to obtain on every coastline on the globe. Nowhere do we find a level surface. For instance, that current which in more northern regions becomes the Gulf Stream is first recognized somewhere south and west of Cape of Good Hope. At this latitude the surface of the earth is rotating to the east at a rate of about 790 miles per hour. At the Equator the rate of rotation is 1,040 miles per hour. These waters, therefore, before passing the Equator, must undergo an acceleration of some 250 miles per hour. Some of this acceleration will be obtained from impulse of the surrounding waters, some possibly from contact with the bottom, but the final acceleration must certainly be reached by the crowding of these waters against the entire eastern shore-line of South America, where deformation of level in the surface-waters must necessarily occur.

It follows, as a consequence, that a deformed and elevated water-surface must exist along the entire coastline of Brazil. Furthermore, we might infer that the south-flowing Brazilian current, like its prototype on the east coast of England, is an escaping, or secondary, current, impelled by the hydrostatic head in existence on those shores, as already suggested by Ferrel.

In the Gulf of Mexico an elevated surface is necessarily established by the united effect of the Equatorial and Gulf Currents. A gradually declining surface from Florida to Nova Scotia and Greenland should also be expected as we pass to the north, due to the retreat of the Gulf Stream from these shores. Some local elevation in the vicinity of the continental projections of Nova Scotia should also appear, from the uplifting effect of the south-flowing Labrador current.

On the European coasts a progressive rising gradient should be found from Africa northward to the shores of Nova Zembla.

Ferrel's law teaches us, therefore, that as long as ocean currents flow upon a rotating earth it is impossible to expect that confluent seas in differing latitudes, on any one coastline, should have the same absolute surface elevation.

It will now be observed that the magnitude of these deformations in oceanic surface as demanded by our law are such as to make their discovery almost a necessity. We are therefore justified in searching the records of levelling operations with the view of learning to what extent Ferrel's deductions may be confirmed by actual fact. Below we quote a few results arrived at from lines of precise levels, extended at different dates through Europe, the United States, and Canada. This list might be considerably enlarged, but the result would be invariably the same. All lines of level confirm Ferrel.

Precise levels in England indicate that "The sea-level of the northern part of the island generally is *higher* than that of the southern part." (U.S. Coast Survey Rep., 1874, p. 256.)

General Tenner found the Baltic Sea to be 0·53 fathom (3·18 feet) higher than the Black Sea. (This line through Russia.) (Smithsonian Report, 1890, p. 312.)

The Encyc. Brit., vol. xxii, p. 708, says: "Lines of level carried across the continent of Europe make the mean sea-level of the Mediterranean, at Marseilles and Trieste, from 2 to 5 feet below that of the North Sea and the Atlantic, at Amsterdam and Brest, *a result which is not easy to explain on mechanical principles*" (my italics).

In *Science*, vol. iii, the results from numerous lines of level in Europe are mentioned as follows:—Bourdalone in 1864 stated the average level of the Mediterranean to be 0·72 metre below that of the Atlantic. General Ibanez has shown the difference of level between Santander and Alicante as 0·66 metre, and between Marseilles and Amsterdam (through Alsace and Switzerland) as 0·80 metre.

Other differences are shown between the Mediterranean and North Sea as follows:—Through Prussian levels, 0·757 metre, *viâ* Alsace 0·809 metre, through Switzerland 0·832 metre, between Trieste and Amsterdam (*viâ* Silesia and Bavaria) 0·59 metre. (*Science*, vol. iii, p. 54.)

In *Science*, vol. vii, p. 75, we are told by Ferrel that the mean level of the harbour of Brest is 1·02 metre higher than the surface-level of Marseilles.

In the United States we find the same condition. Some twelve or fifteen lines of levels from various points on the Atlantic coast result invariably in determining the Gulf of Mexico to be elevated above the waters of the Greater Ocean.

Hilgard in 1884, from three sets of levellings, showed the Gulf at New Orleans as one metre higher than the Atlantic at Sandy Hook. (*Science*, vol. iii, p. 504.)

C. A. Schott shows that the difference of level between Sandy Hook and Lake Ponchartrain is 1·002 metre. (*Science*, vol. vii, p. 102.)

Mr. John F. Hayford, in Appendix No. 8 (U.S. Coast and Geol. Survey Reps., 1899, pp. 397–431), has shown that the average of six lines of precise levels run across Florida, from St. Augustine to Cedar Keys (1892, 1893, and 1894), gave as result the Gulf to be ·2585 metre above the Atlantic. He also shows that a line from Old Point Comfort on the Chesapeake to Biloxi, Miss., found the excess in surface-elevation of the Gulf to be 1·028 metre, and a series of levels from Sandy Hook to Biloxi—evidently not the same lines as those mentioned by Hilgard and Schott—resulted in a difference of ·385 metre. He furthermore gives an excess in the Gulf level of ·175 metre, arrived at by way of a line from Boston and New York to Lake Ontario, thence to Chicago and Duluth, and thence by a most circuitous course to the Gulf. The extraordinary length of this line, however, would seem to render its conclusions less trustworthy than the more direct lines previously mentioned.

In 1883 to 1886 the Canadian Department of Public Works caused a line of levels to be run from Quebec to Rouse's Point, N.Y., where a bench-mark of known altitude above mean sea-level at Sandy Hook had been established by the U.S. Engineers. The result of this line was apparently to establish the fact that the sea-level at Quebec was some $5\frac{1}{2}$ feet *below* that of New York (5·52 feet). This determination was unexpected to this writer, as from the application of Ferrel's formula it would appear that the elevating effect of the southward-flowing

Labrador current, in immediate contact with the shore-line, would be much in excess of the depressing effect of the distant Gulf Stream. It seemed, therefore, impossible to explain mathematically this surprising lack of elevation in the St. Lawrence.

Such explanation, however, no longer seems necessary. In the Trans of the Can. Society of Civil Engineers for 1903, it has been shown by W. B. Dawson that the Admiralty datum at Quebec is 8·58 feet *below* mean sea-level, and that by reason of this the mean sea-level at Quebec had been assumed as about 8 feet too low. Mr. Sproule then pointed out—"This would imply that the observed sea-level in Quebec was 3½ feet *higher* than the sea-level at New York" (p. 124). Ferrel's deductions are thus again confirmed.

A rising gradient of exceptional magnitude is found in the line of levels run by Mr. Bunt in 1837 and 1838 from Portishead on the Bristol Channel, southward to Axmouth on the English Channel. This levelling was made at the instance of the British Association, and was one of the first attempts to introduce extreme accuracy into such labours. The result of nearly 9 inches excess in northern elevation, however, can hardly be ascribed entirely to the cause herein urged. Sir Charles Lyell (Principles, 9th ed., p. 295) has shown that "The rise of a tidal wave above the mean level of a particular sea must be greater than the fall below it." Owing to the extreme range of tides in the Bristol Channel, it seems very probable that the greater portion of the observed elevation of 9 inches may be due to the operation of this last-named law.

It would now seem that the illustrations above given are ample to establish the fact that Ferrel's law is supported by all actual differences in level of which we have knowledge.

Heretofore, these differing elevations have been held as doubtful, absurd, and unexplainable. They have been regarded as in opposition to mechanical principle. The officers of our own Coast Survey have rejected them utterly. They have held the Gulf and Atlantic to be at the same elevation, and have assumed the apparent elevation of the Gulf as due to some mysterious and systematic series of errors in levelling, by which, under some process still more mysterious, these distortions of fact have been made to appear always in one direction. Giving expression to their beliefs, they have also arbitrarily "adjusted" the elevations of some 4,000 bench-marks of the precise level lines of the United States, in an effort to eliminate these unexplainable differences. (See Report Coast and Geod. Survey, 1899, App. 8.)

The logic, the unquestioned value, the simplicity of Ferrel's law, however, now bring fact and theory once again into harmony. In the ocean currents, crowding against, or flowing from, the oceanic coast-lines, we find perfect explanation of all known cases of discrepancy in altitude.

We are now in position to advance one step farther in our examination as to the truth of Playfair's law, and may reason somewhat as follows:—

It will be admitted, I think without question, that the argument above presented has considerable weight, that there is mathematical

support to Farrel's contention, and that when we assume the surface of the sea to be held at abnormal levels of elevation or depression, determined by the rate and direction of flow, there is logic and merit in our position.

Now, then, if these waters are so held at elevations of 3, 5, or 10 feet above or below the normal, depending on the direction and velocity, it is an incontestable deduction that if the slightest change in direction or velocity of these currents takes place, these waters should immediately alter their surface-level in corresponding degree, a rising sea-level at one location being necessarily accompanied by a falling sea-level at some not distant point.

We will now examine as to the probability or possibility of the occurrence of such suggested diversion and variation in currents. This question is almost a new one, but no difficulty should be encountered in entertaining the conception that such changes may have taken place in the past, notwithstanding the dearth of observation in this regard.

Pillsbury's study of the Gulf Stream has shown daily, monthly, and annual variations in flow, but these changes, owing to their short period, probably have little effect on the sea-level at distant points. His observations were not extended over a sufficient number of years to determine cycles of long period, but certain observations in this direction have been made by others, which are of such importance and have such direct bearing on the problem as to entitle them to mention.

In "Prehistoric Europe" Mr. James Geikie, from consideration of the variation in life-forms between Cape Cod and the Bay of Fundy, inferred that the Gulf Stream formerly carried into the north a "much greater body of heated water than now reaches such high latitude" (p. 503).

Dr. James Croll, from study of the fossils in the Carse clays of Scotland, held that when these clays were deposited the mean Winter temperature must have been 10° or 15° lower than at present, and that the Gulf Stream was then "considerably reduced." ("Climate and Cosmology," p. 115.) The recency of this change is affirmed by the fact that these clays contain many buried canoes and other relics of early man.

In Popular Sci. Monthly, vol. xx, p. 668, Mr. James Geikie is again quoted. He therein shows that the climate of North-Western Europe has been, and may yet again be, modified by changes in the flow of the Gulf Stream.

In the Smithsonian Report for 1869 M. Babinet discusses the deterioration in climate of Greenland and the Arctic regions generally during the last few centuries. His conclusion is that the only explanation of many observed facts connected with the movements of ice masses and variation of climate in those regions is found in a "diminution" of the Gulf Stream, and he "boldly affirms" that the current passing around North Cape is now decreasing and carrying less heat than formerly (p. 291).

In the article "Oscillations in the Sea-Level" (Geological Magazine, April, May, and June, 1901) this writer also, like

Babinet, was compelled to invoke a recent diminution in the Gulf Stream to explain the progressive protrusion of the entire northern hemisphere above the level of the sea during the last three centuries.

Other changes in direction or velocity have been either actually observed or inferred from indirect evidence.

Humboldt informs us that a current near the Bahamas flowed to the south-east in 1787. It now flows to the north-west at a velocity of 26 miles a day.

Repeated statements have been made that at different times in the past the fish (cod or herring) industry, off the coasts of Ireland, Scotland, Denmark, and France, has been ruined or injured by the migrations made necessary by the diversions of ocean currents.

Dr. Bessel has shown that the currents of D is Straits formerly ran in an opposite direction. Reclus has shown also that during the Tertiary period the Gulf Stream along the coast of Cuba had direction differing from that of the present.

It will be admitted that the citations above given in no case seem conclusive. They are mostly deductions made by those who have otherwise been unable to explain observed phenomena. Nevertheless, the established positions of many of those who have drawn these conclusions and the profound respect we entertain for their judgment should warrant us in accepting their decisions as most certainly probable.

We may adopt, therefore, as most reasonable, even if not yet firmly established, the following proposition:—Variation and diversion of ocean currents have certainly occurred in the past. It is probable that these changes may be going on to-day, and it is certain we must expect them in the future.

Now, then, it seems a mathematical certainty that if either variation or diversion in flow of ocean currents takes place the surface-levels on all coastlines must change in due proportion, and that these changes must necessarily be in opposite directions in not distant locations. It thus appears that Playfair's law, unchallenged for a century, has during all this time occupied a position to which it had no title. During the full lifetime of the science of geology we have been utilizing the apparent motions in the earth's crust herein considered as types, as living illustrations, of that uplifting of continents, that slow growth in mountain chains, required by our modern doctrines.

Playfair's theory has thus, by its absolute and unquestioned acceptance during this long period, put bar upon progress. No man had courage to question its correctness, therefore no man had occasion to seek other explanation. Now, however, the argument so long unassailable fails us: we find it weak, erroneous, impotent, and when we look back over our recent geologic pathway and see how much we have built upon this frail foundation, upon this uncertain inference of a plastic and mobile crust, one is tempted to ask how can such building be stable? How can such superstructure be more enduring than its supporting fabric?

VI.—A Tabular View of the Cretaceous Polyzoa of the Family Idmoniidæ.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

IN the Geological Magazine for 1906[1] a key of the published figures of the Cretaceous forms referable to the genus *Entalophora* was offered in the hope that by means of it the difficulties attendant on the determination of the species of this genus might be obviated.

A similar key was prepared for the difficult genus *Retecava*; but in its preparation it was found necessary to overhaul other genera of the family Idmoniidæ, a work which resulted in reducing all the genera of this family to a tabular form for the determination of the species. These tables are here given for the use of the collector in determining the forms and as a guide to the descriptions in the British Museum Catalogue.

I. The Genera comprising the Idmoniidæ.

The Idmoniidæ are defined as Cyclostomata Tubulata in which there is a 'reverse face' of the zoarium without apertures, and those on the 'obverse face' are arranged in rows symmetrically about the middle line.

Like other families of Cretaceous Polyzoa, the Idmoniidæ include encrusting and branching forms which pass in regular sequence from strap-shaped zoœcia through discoid to erect forms. There is no foliate genus like *Diastopora*[2] among the Diastoporidæ. The simplest genus, *Idmonea*, resembles forms of *Proboscina* such as *P. radiolitorum* and *P. anomala*; the former, as pointed out by Gregory,[3] being intermediate between *Proboscina* and *Idmonea*, thus suggesting the origin of the family.

The following is a tabular view of the genera included in the family:—

IDMONIIDÆ.

A. *Zoarium encrusting.*

I. Zoarium strap-shaped (like *Proboscina*), or if discoid the zoœcia are arranged on strap-shaped ridges; apertures in alternate, pinnately-arranged rows.

a. Apertures in single lateral series ... ... *Idmonea.*

b. Apertures in double lateral series (except at extreme proximal end) ... ... *Reptofascigera.*

(Only species, *R. alternata*, d'Orbigny, 1853: Pal. Franç. Bry. Crét., pl. 744, figs. 4–6.)

II. Zoarium discoid (like *Berenicea*); zoœcia in radially-arranged rows ... ... *Phalangella.*

(Only Cretaceous species, *Berenicea radians*, Novak, 1877, Bry. Böhm. Kr.: Denk. Ak. Wiss. Wien., vol. xxxvii, pt. 2, pl. iv, figs. 15–18.)

B. *Zoarium erect, of hollow branches* ... ... *Semiclausa.*

[1] W. D. Lang, "A Key to the Published Figures of the Cretaceous Forms of *Entalophora*": Geol. Mag., 1906, p. 462.

[2] Cf. a similar case in the Eleidæ: see Lang, Geol. Mag., 1906, p. 60.

[3] J. W. Gregory: Brit. Mus. Cat. of Cretaceous Bryozoa, vol. i (1899), p. 150.

C. *Zoarium erect, of solid branches.*

I. No unpaired median nor multiple median series of apertures.

a. Apertures in double lateral series ... ... *Bitubigera.*

(Only Cretaceous species, *B. compressa*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 1.)

b. Apertures in single lateral series.

1. Apertures circular or tear-shaped. In the former case longitudinal grooves, slots, or circular depressions are present on the zoarium; in the latter case the reverse face is very narrow.

α. Zoarium very compressed in a plane at right angles to that of the obverse and reverse faces; reverse face well developed ... ... *Bicrisina.*

β. Zoarium not very compressed; reverse face very narrow *Sulcocava.*

2. Apertures circular (tear-shaped in two species of *Retecava*, but in both the reverse face is well developed). If longitudinal grooves or depressions are present on the zoarium, it is never very compressed in a plane at right angles to that of the obverse and reverse faces (as in *Bicrisina*), nor is the reverse face reduced (as in *Sulcocava*).

α. Branches very compressed in a plane at right angles to that of the obverse and reverse faces; or if not so compressed the reverse face is very narrow ... ... *Reticrisina.*

β. Branches cylindrical or moderately compressed; reverse face well developed.

a. An 'axial rod' more or less developed on the reverse side ... ... *Retecava.*

b. No 'axial rod' ... ... *Crisina.*

II. An unpaired median series of apertures; lateral series simple *Tervia.*

III. A multiple median series of apertures; lateral series multiple *Pergenselia.*

(Only species—

Idmonea geniculata, von Hagenow, 1851: Bry. Maastr. Kr., pl. iii, fig. 5.

Retepora clathrata, pars, Goldfuss, 1827: Petrefact. Germ., vol. i, pl. ix, figs. 12*e–f*.

Pergensella geniculata, Gregory, 1899: Brit. Mus. Cat. Cret. Polyzoa, p. 210, figs. 19–20.)

Until the forms consisting of solid branches are reached, the development of the family appears fairly simple. The genus *Semiclausa*, consisting of hollow tubes, probably arose, like the hollow Diastoporas (such as *D. ramosissima*, d'Orbigny), by the folding of an erect unilamilar zoarium. Such a form has not yet been found; but it only needs the erection of the distal end of an *Idmonea* to produce it. Until the proximal ends of d'Orbigny's two species of *Semiclausa* are found nothing definite can be known of their origin. For it is conceivable that they may be encrusting forms which have grown on some perishable cylindrical base, such as a stem of seaweed, the decomposition of which has left the encrusting Polyzoan in the form of a hollow tube.

Gregory has produced evidence of the origin of *Crisina* in the shape of a discoid base of this genus resembling *Phalangella*.[1] This is exactly comparable with the specimen he figures of an *Entalophora* arising directly from a *Berenicea*-like base.[2]

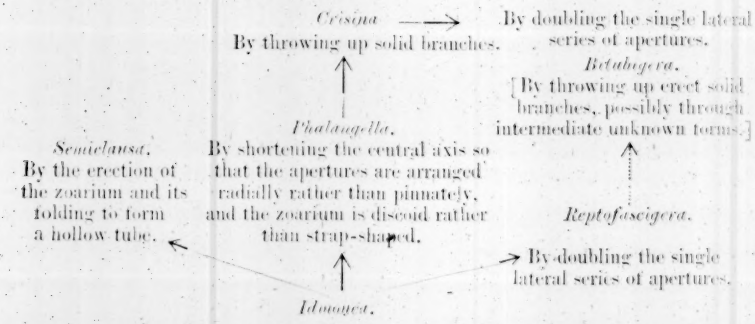
The origin of *Reptofascigera* from *Idmonea* is clearly shown in

[1] J. W. Gregory: Brit. Mus. Cat. Cret. Bryozoa, vol. i (1899), p. 159, fig. 11.
[2] J. W. Gregory: loc. cit., p. 217, fig. 26.

d'Orbigny's figure of the only species of that genus. At the extreme proximal end of the zoarium the apertures are in single lateral series, i.e. proximally the form is an *Idmonea*.

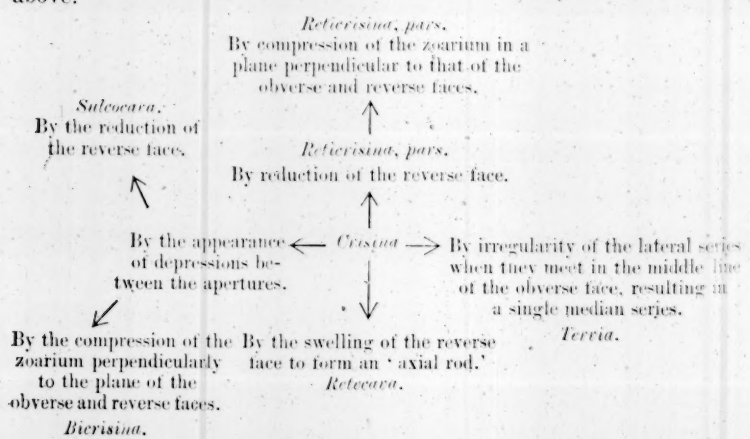
Without the knowledge of the proximal end of *Bitubigera* it is uncertain whether this form arose directly from *Crisina*, as *Reptofascigera* from *Idmonea*, by doubling the single lateral series of apertures, or through intermediate unknown forms from *Reptofascigera*.

The following diagram summarizes these suggestions as to the origin of the simpler genera:—


Crisina
By throwing up solid branches.
By doubling the single lateral series of apertures.
Bitubigera.
[By throwing up erect solid branches, possibly through intermediate unknown forms.]
Phalangella.
By shortening the central axis so that the apertures are arranged radially rather than pinnately, and the zoarium is discoid rather than strap-shaped.
Semiclausa.
By the erection of the zoarium and its folding to form a hollow tube.
Reptofascigera.
By doubling the single lateral series of apertures.
Idmonea.

The forms distributed among the remaining genera are not easy to group. *Tervia*, *Reticrisina*, and *Crisina* (restricted) are considered by Gregory as subgenera of *Crisina*; and there is no doubt of their close relationship. But the species of *Crisina* and of *Retecava* are very hard to separate, and the latter genus resembles *Sulcocava* and *Bicrisina*. *Pergensella* is very isolated, and there is no evidence of its origin.

The following scheme suggests the main lines of development, but it does not represent all the facts, for species of intermediate nature occur between various genera, showing that probably the genera are artificial. Hence the clumsy definitions in the table of genera given above.


Reticrisina, pars.
By compression of the zoarium in a plane perpendicular to that of the obverse and reverse faces.
Sulcocava.
By the reduction of the reverse face.
Reticrisina, pars.
By reduction of the reverse face.
By the appearance of depressions between the apertures.
Crisina
By irregularity of the lateral series when they meet in the middle line of the obverse face, resulting in a single median series.
Tervia.
By the compression of the zoarium perpendicularly to the plane of the obverse and reverse faces.
Bicrisina.
By the swelling of the reverse face to form an 'axial rod.'
Retecava.

II. The Subdivisions of the Genera.

In the following tables for the subdivision of the genera references are given only to those forms which are figured; for it is often almost impossible to be sure of the species intended by descriptions unaccompanied by figures, in the case of these obscure forms. But as these tables are not intended to show natural relationships, but only as keys to help the collector to determine the forms described in the British Museum Catalogue, the synonymy of the species is assumed to be that given in the Catalogue. The remarks prefacing the table of the genus *Entalophora* in the former paper are applicable here. The genera *Crisina* and *Retecava* are taken together, owing to the difficulty of separating them in practice. Theoretically a solid rod-like thickening occupies the reverse side of the zoarium in *Retecava*; while that of *Crisina* is not wider than the obverse side. But forms of *Retecava* occur, such as *R. cypris* (d'Orbigny) and *R. grandis* (d'Orbigny), in which the 'axial rod' is reduced or hardly distinguishable; while in *Crisina ligeriensis*, d'Orbigny, the reverse side is decidedly rod-like. The morphological significance of the 'axial rod' stands or falls with that of the 'canaux de renforcement' of Pergens,[1] structures which can only be identified in longitudinal sections.

Idmonea.

I. Zoarium of one or two (connected only at their proximal ends) strap-shaped zoœcium-bearing ridges, each of which may have its own 'selvage.'
  A. Zoarium long and narrow (about six times as long as broad), with or without a 'selvage.'
    a. Zoœcia emergent.
      Reptotubigera cristata, Meunier & Pergens, 1885, Nouv. Bry. Crét. Sup.: Mém. Soc. Roy. Malac. Belge, pl. ii, fig. 7.
      Idmonea cristata, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. viii, figs. 4*a*, 4*b*.
    b. Zoœcia immersed.
      Idmonea alpes, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. viii, figs. 2, 3.
  B. Zoarium short (about three times as long as broad), rapidly becoming broader distally, without a 'selvage.'
    Idmonea cirgula, d'Orbigny, 1851: Bry. Crét., pl. 631, figs. 15–17.
    Reptotubigera simplex, de Loriol, 1853: Invert. Mt. Salève, pl. xvi, fig. 3.
II. Zoarium of many zoœcium-bearing ridges, rising from a common 'selvage.'
  A. Ridges short (seldom more than three times, generally about twice as long as broad) and straight.
    a. Two to three zoœcia in a lateral series.
      Reptoclausa neocomiensis, de Loriol, 1863: Invert. Mt. Salève, pl. xvii, fig. 7.
    b. Three or four zoœcia in a lateral series.
      Reptoclausa obliqua, d'Orbigny, 1853: Bry. Crét., pl. 765, figs. 3, 4.
    c. Five or six zoœcia in a lateral series.
      Reptoclausa neocomiensis, d'Orbigny, 1853: Bry. Crét., pl. 765, figs. 1, 2.

[1] Pergens, 1890, "Revision des Bryozoaires du Crétacé," p. 311; and J. W. Gregory, 1899, Brit. Mus. Cat. Cret. Bry., vol. i, p. 149.

B. Ridges long (six or more times as long as broad) and often wavy.
a. Four to six zooecia in the breadth of a ridge.
Lophoclepas Hagenowi, Sharpe, 1854: Quart. Journ. Geol. Soc., pl. v, fig. 7.
Idmonea Hagenowi, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., pl. viii, figs. 1*a*, *b*.
b. Five to seven zooecia in the breadth of a ridge.
Reptoclausa meandrina, de Loriol, 1868, Val. Arz.: Pal. Suisse, ser. iv, pt. 2, pl. vi, fig. 1.

Semiclausa.

A. Zoarium a flattened tube: zooecium-bearing ridges arranged pinnately.
Semiclausa alternata, d'Orbigny, 1853: Bry. Crét., pl. 764, figs. 6–10.
B. Zoarium a tube, triangular in cross-section: zooecium-bearing ridges arranged in longitudinal rows.
Semiclausa angulosa, d'Orbigny, 1853: Bry. Crét., pl. 764, figs. 11–13.

Bicrisina.

A. Depressions between the apertures circular: apertures about twelve to fifteen in a series; reverse face occupies about half the zoarium.
Bicrisina Gaudryi, Pergens, 1890: Revision, pl. xiii, fig. 2.
B. Depressions between the apertures tear-shaped: apertures about eight in a series; reverse face not so extensive as in *B. Gaudryi*.
Reticulipora cultrata, d'Orbigny: 1851, Bry. Crét., pl. 611, figs. 6–10; 1853, Bry. Crét., pl. 768, figs. 11–15.

Sulcocava.

A. Apertures circular.
I. Zoarium strongly fluted.
a. Distance between apertures of the same series about one diameter of an aperture. Reverse face almost obliterated.
Sulcocava sulcata, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 1–3.
b. Distance between apertures of the same series less than one diameter of an aperture. Reverse face fairly developed.
Sulcocava costulata, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pt. 1; pl. ii, fig. 1.
II. Zoarium with slot-shaped depressions between the apertures
Sulcocava cristata, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i. p. 212, fig. 21.
Sulcocava gracilis, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i. p. 214, fig. 23.
III. Zoarium with faint longitudinal depressions between the apertures.
Laterocava gracilis, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 17–20.
B. Apertures tear-shaped.
I. Apertures about eight in a series.
Sulcocava cristata, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 4–8.
Sulcocava lacryma, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 9–12.
II. Apertures about twelve in a series.
Laterocava rustica, d'Orbigny, 1853: Bry. Crét., pl. 789, figs. 13–16.

Reticrisina.

A. Branches of zoarium form a regular, dense network, the meshes of which are hexagons or squares.
Reticulipora ligeriensis, d'Orbigny, 1851: Bry. Crét., pl. 609, figs. 1–6.
Reticulipora gironaina, d'Orbigny, 1851: Bry. Crét., pl. 609, figs. 7–12.

B. Branches of zoarium, if anastomosing, form only a loose network, the meshes of which are flame-shaped.

I. Zoarium very compressed in a plane at right angles to that of the obverse and reverse faces, being about five or six times as high as wide.

a. Apertures about seven in a series.

Reticulipora papyracea, d'Orbigny: 1851, Bry. Crét., pl. 611, figs. 1–5; 1853, Bry. Crét., pl. 768, figs. 3–10.

Reticulipora complanata, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 10.

Retiervisina papyracea, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, pl. ix, figs. 1–3.

b. Apertures twelve to twenty in a series.

Reticulipora obliqua, d'Orbigny: 1851, Bry. Crét., pl. 610, figs. 1–5; 1853, Bry. Crét., pl. 768, figs. 1, 2.

Retiervisina obliqua, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 177, fig. 13; pl. viii, figs. 8, 9.

II. Zoarium compressed in a plane at right angles to that of the obverse and reverse faces, but only three or four times as high as wide. Apertures about nine in a series.

Cricopora gradata, Leymerie, 1851, Type. Pyren. par. à Craie: Mém. Soc. géol. France, ser. II, vol. iv, pl. ix, fig. 7.

III. Zoarium only slightly, if at all, compressed in a plane at right angles to that of the obverse and reverse faces.

Retepora disticha, *pars*, Goldfuss, 1827: Petref. Germ., vol. i, pl. ix, figs. 15*c*, *d*.

Idmonea disticha, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 8.

Idmonea maculata, *pars*, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, figs. 3*e–g*.

Tubigera distans, d'Orbigny, 1853: Bry. Crét., pl. 746, figs. 2–6.

Ceriopora subcompressa, von Hagenow, 1845: in Geinitz, Grundr. Verst., pl. xxiii*b*, fig. 15.

Idmonea subcompressa, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. ii, fig. 7.

Stichopora regularis, d'Orbigny, 1851: Bry. Crét., pl. 613, figs. 11–15.

Tubigera aniiqua, d'Orbigny, 1853: Bry. Crét., pl. 746, fig. 1.

Tubigera distans, d'Orbigny, 1853: Bry. Crét., pl. 746, figs. 7–11.

Retervisina disticha, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 184, fig. 14.

Tervia.

A. Zoœcia one or two in a lateral series.

1. Distance between the series of apertures two to three times the diameter of an aperture; zoarium cylindrical; zoœcia immersed; distance between apertures of the same series one diameter of an aperture.

Crisina subgracilis, d'Orbigny, 1851: Bry. Crét., pl. 614, figs. 6–10.

Idmonea subgracilis, Pergens, 1890: Revision, pl. xii, fig. 2.

2. Distance between the series of apertures four times the diameter of an aperture; zoarium flattened in the plane of the obverse and reverse faces; zoœcia immersed; distance between apertures of the same series one diameter of an aperture.

Filisparsa pulchella, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 7.

T. subgracilis.

3. Distance between the series of apertures four to seven times the diameter of an aperture.

a. Apertures one only in a series; zoarium flattened in the plane of the obverse and reverse faces; zoœcia immersed or boundaries slightly shown.

Filisparsa simplex, von Reuss, 1874, Bry. ob. Plän.: Palæontogr., vol. xx, pt. 2, pl. xxv, fig. 1.

b. Apertures one to two in a series; zoarium cylindrical; zoœcia immersed, or boundaries shown, or slightly emergent; apertures of the same series distant half a diameter or an aperture.

Idmonea Mueller, Beissel, 1865, Bry. Aach. kr.: Nat. Verh. Holl. Maat. Wet., ser. ii, vol. xxii, p. 77, pl. ix, figs. 105–106.

Filisparsa Mueller, Beissel, 1865: op. cit., pl. x, figs. 129–131.

T. Mueller.

B. Zoœcia alternately two and three in a lateral series; zoarium flat on the reverse side, triangular in section; zoœcia immersed, with boundaries shown; zoœcia of same series distant two to three diameters of an aperture, those of different series four to five diameters of an aperture.

Idmonea decurrens, Počta, 1892, Mech. korye. Hory.: Ceska. Ak. Fr. Jos. Praze, sect. 2, pl. ii, figs. 3–6.

T. decurrens.

C. Zoœcia three to four in a lateral series.

1. Zoarium clavate; zoœcia immersed; zoœcia of same series distant one to two diameters, and those of different series four to five diameters of aperture.

Claustubigera depressa, d'Orbigny, 1853: Bry. Crét., pl. 747, figs. 1–5.

T. subgracilis.

2. Zoarium compressed in a plane at right angles to that of the obverse and reverse faces; zoœcia immersed, but their boundaries are well marked; zoœcia of the same series distant one to one and a half times, those of different series three to four times, the diameter of an aperture.

Terebellaria Gaudini, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, pl. ix, fig. 9.

T. Gaudini.

3. Zoarium cylindrical or flattened in a plane parallel to that of the obverse and reverse faces.

a. Zoarium with 'dorsal processes' without apertures projecting from the reverse face; zoarium cylindrical, but reverse face is flat; zoœcia immersed, with boundaries very slightly shown; zoœcia of the same series distant one-half, those of different series three to four times, the diameter of an aperture.

Terebellaria gibbera, Gregory, 1899: B.M. Cat. Cret. Bry., vol. i, p. 174, fig. 12.

T. gibbera.

b. Zoarium without 'dorsal processes.'

α. Distance between the different series of apertures one and a half to two and a half times the diameter of an aperture; zoarium flattened in a plane parallel to obverse and reverse faces; reverse face flat or slightly concave; zoœcia immersed, but boundaries may be prominent. Apertures of same series distant one-quarter to one diameter of an aperture.

Idmonea dorsata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 10.

Idmonea dorsata, d'Orbigny, 1853: Bry. Crét., pl. 748, figs. 16–19.

Idmonea d rsata,[1] Pergens, 1890: Revision, pl. xii, fig. 5.

β. Distance between the different series of apertures three diameters of an aperture.

1. Distance between apertures of the same series one and a half to two diameters of an aperture; zoarium flattened in a plane parallel to that of the obverse and reverse faces; zoœcia immersed, boundaries not shown or hardly shown.

Idmonea dorsata, var. *Faxcensis*, Pergens & Meunier, 1887, Bry. gar. Faxé: Ann. Soc. Roy. Malac. Belge, vol. xxi, pl. xi, fig. 1.

T. dorsata.

2. Distance between apertures of the same series one-half the diameter of an aperture; zoarium cylindrical, zoœcia immersed.

Retepora distecha, *pars*, Goldfuss, 1827; Petref. Germ., vol. i, pl. ix, figs. 15*g*, *h*.

[1] Most of the characters of *I. dorsata* are not shown on Pergens' figure. There are remains of what might have been 'dorsal processes.'

Crisina–Retecava.

I. Zoarium cylindrical or subtriangular or subquadrangular in cross-section, or flattened in a plane at right angles to the obverse and reverse faces.
  II. Lateral series quite irregular.
    a. Zoarium with a strong, blunt median keel 1
    b. Zoarium with a strong, thin median keel 2
  III. A few scattered apertures between the somewhat wavy lateral series ... 3
  IV. Lateral series regular.
    a. Apertures elongate in a proximal-distal direction.
      1. Apertures about four in a series 4
      2. Apertures ten or more in a series 5
    b. Apertures circular or nearly so.
      1. Reverse face convex.
        α. Apertures one or occasionally two in a series 6
        β. Apertures 2–6 in a series.
          a. No decided keel on the obverse face, nor much compressed.
            1. Apertures decreasing in size from the middle of the obverse face outwards 7
            2. Apertures all of one size.
              α. Zoœcia immersed and boundaries to zoœcia not strongly marked.
                a. Series of apertures do not reach the middle line of obverse face.
                  1. Branches connected by cross-bars which bear no apertures 8
                  2. Branches with no cross-bars.
                    α. Distance between series of apertures 5–8 or more times the diameter of aperture.
                      a. Apertures two in a series, branches take a zigzag course 9
                      b. Apertures 3–4 in a series; those of same series distant about half diameter of aperture ... 10
                      c. Apertures 4–5 in a series; those of same series distant three-quarters diameter of aperture ... 11
                    β. Distance between series of apertures 2–3 diameters of apertures 12
                b. Series of apertures meet the middle line.
                  1. Apertures of same series distant less than one diameter of aperture.
                    α. Apertures of different series distant 1–3 diameters of aperture 13
                    β. Apertures of different series distant about three diameters of aperture 14
                    γ. Apertures of different series distant 4–8 diameters of aperture 15
                  2. Apertures of same series distant one diameter of aperture 16
              β. Zoœcia immersed, but boundaries of zoœcia are strongly marked.
                1. Zoœcia two only in a series 17
                2. Zoœcia three (occasionally two) in a series 18
                3. Zoœcia four in a series 19
                4. Zoœcia six in a series (series of apertures do not reach the middle line) 20
              γ. Zoœcia emergent 21
          b. A decided keel on obverse face or decidedly compressed.
            1. Apertures of same series distant one or more than one diameter of aperture.
              α. Reverse face marked with linear depressions 22
              β. Reverse face marked with reticular depressions 23
            2. Apertures of same series distant less than one diameter of aperture.

α. Apertures of different series distant 3–6 diameters of aperture 24
β. Apertures of different series distant 1½–3 diameters of aperture 25
γ. Apertures 6–15 in a series.
a. Series of apertures distant 3–4 diameters of aperture 26
b. Series of apertures distant 2–3 diameters of aperture.
1. Apertures of the same series distant ½–2 diameters of aperture 27
2. Apertures of the same series distant ¼–1 diameter of aperture 28
2. Reverse face flat or concave, apertures 3–8 in a series 29
B. Zoarium flattened in a plane parallel to the obverse and reverse faces.
I. Reverse face flat or convex, series of apertures close together, apertures 5–6 in a series 30
II. Reverse face concave, series of apertures far apart, apertures 3–5 in a series 31
C. Zoarium clavate.
I. Reverse face convex, apertures 3–7 in a series 32
II. Reverse face concave, apertures 6 in a series 33

1. *Reticulipora ramosa*, d'Orbigny, 1851: Bry. Crét., pl. 610, figs. 7–11... ... ... *R. clathrata.*
2. *Reticulipora sagena*, Gabb & Horn, 1860, New Amer. Foss.: Journ. Acad. Nat. Sci. Phil., ser. II, vol. iv, pl. lxix, figs. 30–32 ... ... *R. sagena.*
Idmonea dichotoma, Gabb & Horn, 1862, Mon. Foss. Poly. N. Amer.: Journ. Acad. Nat. Sci. Phil., ser. II, vol. v, pl. xxi, fig. 64 ... ... *R. dichotoma.*
3. *Reticava areolata*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. iii, fig. 9 ... ... *R. areolata.*
4. *Idmonea linéata*, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 13 ... ... *R. pseudodisticha.*
5. *Idmonea gibbosa*, von Hagenow, 1851: loc. cit., pl. ii, fig. 14 ... ... *R. gibbosa.*
6. *Crisina unipora*, d'Orbigny, 1851: loc. cit., pl. 613, figs. 1–5 ... ... *C. unipora.*
Crisina elegans, d'Orbigny, 1851: loc. cit., pl. 613, figs. 6–10... ... ... ,,
Idmonea francorum, Pergens, 1890: Revision, pl. xiii fig. 1. ,,
Retepora gracilis, von Hagenow, 1846: in Geinitz, Grundr. Verst., pl. xxiii *b*, fig. 4 ... ... ,,
Crisina unipora, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. viii, figs. 5 and 6 ... ... ,,
Idmonea unipora, Beissel, 1865, Bry. Aach. kr.: Nat. Verh. Holl. Maatsch. Wet., ser. II, vol. xxii, pl. viii, figs. 97–99 ... ... *R. cretacea.*
7. *Bicrisina Abbotti*, Gabb & Horn, 1862, Foss. Poly. N. Amer.: Journ. Acad. Nat. Sci. Phil., ser. II, vol. v, pl. xxi, fig. 65 ... ... *R. Abbotti.*
Idmonea pseudodisticha, Marsson, 1887: loc. cit., pl. ii, fig. 8*b* ... ... ?
8. *Retepora cancellata*, Goldfuss, 1829: Petref. Germ., vol. i, pl. xxxvi, fig. 17 ... ... *R. cancellata.*
Retepora cancellata, von Hagenow, 1846: in Geinitz, Grundr. Verst., pl. xxiii *b*, fig. 2 ... ... ,,
Idmonea cancellata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 7 ... ... ,,
Idmonea cancellata, d'Orbigny, 1853: loc. cit., pl. 748, figs. 20–23 ... ... ,,
9. *Retepora gracilis*, von Hagenow, 1846: in Geinitz, Grundr. Verst., pl. xxiii *b*, fig. 4... ... ... *C. unipora.*
10. *Crisina subgradata*, d'Orbigny, 1851: loc. cit., pl. 612, figs. 6–10... ... ... *R. subgradata.*
Idmonea pseudodisticha, Marsson, 1887: loc. cit., pl. ii, fig. 8*a* ... ... ?
Idmonea laticosta, Marsson, 1887: loc. cit., pl. ii, fig. 11 *R. pseudodisticha.*

11.	*Idmonea commutata*, Marsson, 1887 : loc. cit., pl. ii, fig. 10	*R. pseudodisticha.*
12.	*Idmonea cretacea*, Milne Edwards, 1838, Mém. Cris. : Amer. Sci. Nat. Zool., ser. II, vol. ix, pl. xii, fig. 5. Lonsdale, 1850 : in Dixon, Geol. Sussex, pl. xviiia, figs. 5, 5*a–h*	*R. cretacea.*
	Retevara cretacea, Gregory, 1899 : loc. cit., pl. ix, fig. 8.	,,
	Idmonea Dixoniana, Mantell, 1844 : Med. Creat., vol. i, p. 284, figs. 6, 12	,,
	Crisidmonea macropora, Marsson, 1887 : loc. cit., pl. ii, fig. 13	,,
	Retepora lichenoides, Goldfuss, 1827 : loc. cit., pl. ix, fig. 13	*R. lichenoides.*
	Idmonea lichenoides, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, fig. 6	,,
	Calophyma granulatum, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, fig. 17	,,
	Idmonea carantina, d'Orbigny, 1853 : loc. cit., pl. 748, figs. 1–5	*R. carantina.*
13.	*Idmonea disticha*, Michelin, 1845 : Icon. Zooph., pl. lii, fig. 18	*C. cenomana.*
	Crisina cenomana, d'Orbigny, 1851 : loc. cit., pl. 614, figs. 1–5	,,
	Idmonea cenomana, Pergens, 1890 : loc. cit., pl. xii, fig. 3.	,,
	Retepora disticha, Goldfuss, 1827 : loc. cit., pl. ix, figs. 15*e*, *f*	*R. pseudodisticha.*
	Idmonea maculata, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, figs. 3*a–d*	,,
	Heterocrisina Abbotti, Gabb & Horn, 1860 : Journ. Acad. Nat. Sci. Phil., ser. II, vol. iv, pl. lxix, figs. 45–47 ...	*R. Abbotti.*
14.	*Idmonea striatola*, Marsson, 1887 : loc. cit., pl. ii, fig. 9 ...	*R. carinata.*
15.	*Idmonea disticha*, Michelin, 1845 : loc. cit., pl. lii, fig. 18	*C. cenomana.*
	Idmonea insignis, Marsson, 1887 : loc. cit., pl. ii, fig. 12 ...	*R. insignis.*
16.	*Idmonea cypris*, d'Orbigny, 1853 : loc. cit., pl. 749, figs. 7–10	*R. cypris.*
17.	*Idmonea francorum*, Pergens, 1890 : loc. cit., pl. xiii, fig. 1	*C. unipora.*
18.	*Idmonea cretacea*, M. Edwards, 1838 : loc. cit., pl. xii, fig. 5	*R. cretacea.*
	Idmonea communis, d'Orbigny, 1853 : loc. cit., pl. 750, figs. 6–10	,,
	Idmonea prima, Poeta, 1892, Mech. Koryc. Hory. : Cesk. Akad. Cis. Fr. Jos., sect. 2, pl. ii, figs. 7–11	*C. cenomana.*
19.	*Crisina normaniana*, d'Orbigny, 1851 : loc. cit., pl. 612, figs. 1–5	*C. cenomana.*
20.	*Idmonea grandis*, d'Orbigny, 1853 : loc. cit., pl. 749, figs. 16–19	*R. grandis.*
21.	*Idmonea pseudodisticha*, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, fig. 9. D'Orbigny, 1853 : loc. cit., pl. 749, figs. 1–6	*R. pseudodisticha.*
	Idmonea irregularis, Beissel, 1865 : loc. cit., pl. viii, figs. 102–104	,,
	Idmonea unipora, Beissel, 1865 : loc. cit., pl. viii, figs. 98, 100	*R. cretacea.*
	Crisina cenomana, var. *triangularis*, d'Orbigny : Gregory, 1899, loc. cit., pl. viii, fig. 7	*C. cenomana*, var. *triangularis.*
22.	*Idmonea lichenoides*, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, fig. 6	*R. lichenoides.*
23.	*Idmonea geometrica*, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, fig. 11	*R. geometrica.*
24.	*Crisina triangularis*, d'Orbigny, 1851 : loc. cit., pl. 612, figs. 11–15	*C. cenomana.*
	Crisina ligeriensis, d'Orbigny, 1851 : loc. cit., pl. 614, figs. 11–15	,,
25.	*Retevara carinata*, Gregory, 1899 : loc. cit., p. 198, fig. 17	*R. carinata.*
	Idmonea sulcata, von Hagenow, 1851 : Bry. Maastr. kr., pl. ii, fig. 12	,,

	Idmonea cytherea, d'Orbigny, 1853: loc. cit., pl. 750, figs. 11–15	*R. carinata.*
26.	*Crisina ramosa*, d'Orbigny, 1851: loc. cit., pl. 611, figs. 11–15	*R. ramosa.*
	Idmonea maculata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 4	,,
	Idmonea divaricata, Ubaghs, 1865, Bry. Schicht. Maastr.: Verh. naturh. Ver. Progss. Rheinl., vol. xxii, pl. iii, fig. 8	,,
27.	*Retepora clathrata*, Goldfuss, 1827: loc. cit., pl. x, figs. 12*c*, *d*	*R. clathrata.*
	Idmonea clathrata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 2	,,
	Retecava clathrata, d'Orbigny, 1853: pl. 790, figs. 5–9.	,,
	Idmonea verriculata, von Hagenow, 1851: Bry. Maastr. kr., pl. ii, fig. 5	,,
28.	*Idmonea carinata*, Roemer, 1840: loc. cit., pl. v, fig. 20.	*R. carinata.*
29.	*Idmonea filiformis*, d'Orbigny, 1853: loc. cit., pl. 750, figs. 1–5	*R. pseudodistichа.*
	Idmonea angulosa, d'Orbigny, 1853: loc. cit., pl. 748, figs. 11–15	*C. angulosa.*
	Idmonea marginata, d'Orbigny, 1853: loc. cit., pl. 749, figs. 20–23	*C. marginata.*
	Idmonea lata, d'Orbigny, 1853: loc. cit., pl. 748, figs. 6–10.	,,
	Idmonea excavata, d'Orbigny, 1853: loc. cit., pl. 749, figs. 11–15	,,
	Idmonea calypso, d'Orbigny, 1853: loc. cit., pl. 747, figs. 11–14	*C. cenomana.*
30.	*Idmonea plana*, Pocta, 1892: loc. cit., pl. ii, figs. 1, 2 ...	*C. plana.*
31.	*Clavitubigera navicularis*, Beissel, 1865: loc. cit., pl. viii, figs. 94–96	*C. navicularis.*
32.	*Clavitubigera convexa*, d'Orbigny, 1853: loc. cit., pl. 746, figs. 12–15	*C. convexa.*
	Clavitubigera augustata, d'Orbigny, 1853: loc. cit., pl. 746, figs. 16–20	,,
33.	*Clavitubigera excavata*, d'Orbigny, 1853: loc. cit., pl. 747, figs. 6–9	*C. Fischeri.*
	Idmonea Fischeri, Pergens, 1890: loc. cit., pl. xii, fig. 4.	,,

VII.—The Comparative Fertility of the Soil above certain Geological Formations.

By James Love, F.G.S., F.R.A.S.

WHILE travelling over the country it may be noticed that the land is not uniformly fertile. In some places there is greater luxuriance and greater variety of plant life than in others. The question which such observations call forth is what is the cause of these differences? An attempt has been made to give some sort of answer to this question in the following manner:—A limited area has been selected which is traversed by a number of geological formations, and the plants growing on that area have been catalogued. The area selected in the present instance is the county of Surrey, that being the county which is best known to me. Surrey is too small a county to have any difference of climate. The differences of altitude would probably bring about some variety in the flora, but the differences of latitude could scarcely have any appreciable effect. The county is, however, large enough to include a dozen different rock

formations within its boundary, and it seems fair to presume that these may have a considerable influence in determining the distribution and variation of its flora. Of the 1,310 species of plants figured and described in Bentham's British Flora, about 1,000, or approximately three-quarters of the whole flora, have been found growing in Surrey: these are arranged with the rocks over which they grow in the following order of diminishing numbers:—

Rock Formations.	Species of Plants.
Lower Greensand	711
Gravel	655
Chalk	523
Bagshot Beds	513
London Clay	496
Weald Clay	364
Gault and Upper Greensand	356
Alluvium	302
Hastings Beds	281
Woolwich and Reading Beds	214
Thanet Beds	204

Perhaps it might be supposed that these numbers of plants would accord with the extent of area of the rocks over which they are growing. To determine this point the areas of the rocks which form the surface of the land within the county boundary of Surrey have been measured, and are arranged in the following order of diminishing areas, the figures giving the number of square miles of each formation:—

Rock Formations.	Areas.
Weald Clay	165·4 sq. miles
Lower Greensand	149·6 ,,
Chalk	119·32 ,,
London Clay	113·27 ,,
Bagshot Beds	93·84 ,,
Gravel	63·84 ,,
Woolwich and Reading	23·84 ,,
Alluvium	22·1 ,,
Gault and Upper Greensand	15·7 ,,
Hastings Beds	11·4 ,,
Thanet Beds	4·33 ,,

Dividing the number of species of plants growing over each formation by the number of square miles of the exposed surface of that formation will give the number of species of plants per square mile of rock surface. This may be called the density of species. They are the following, again in the order of diminishing numbers:—

Rock Formations.	Species per Square Mile.
Thanet Beds	47·1
Hastings Beds	24·65
Gault and Upper Greensand	22·65
Alluvium	13·66
Gravel	10·26
Woolwich and Reading	9·0
Bagshot Beds	5·47
Lower Greensand	4·75
Chalk	4·39
London Clay	4·38
Weald Clay	2·21

The result may be summarised in the following table, in which the rock formations are arranged in the descending order of stratification:—

Rock Formations.	Number of species.	Number of sq. miles.	Number of species per sq. mile.
Alluvium	302	22·1	13·66
Gravel	655	63·84	10·26
Bagshot Beds	513	93·84	5·47
London Clay	496	113·27	4·38
Woolwich and Reading ...	214	23·84	9·0
Thanet Beds	204	4·33	47·1
Chalk	523	119·32	4·39
Upper Greensand and Gault	356	15·7	22·65
Lower Greensand	711	149·6	4·75
Weald Clay	364	165 4	2·21
Hastings Beds	281	11·4	24·65

REVIEWS.

I.—The Progress of Palæontology.

Palæontographical Society, Vol. LX. Issued for 1906 (December, 1906). Printed for the Society (agents, Messrs. Dulau & Co.). 4to. Containing:—

1. The Pleistocene Bears, Vol. II, Part 2; by Prof. S. H. Reynolds, M.A., F.G.S. pp. 1–35, pls. i–viii.
2. The Fishes of the Old Red Sandstone, Part II, No. 3: the Asterolepidæ; by Dr. R. H. Traquair, F.R.S. pp. 119–130, pls. xxvii–xxxi.
3. The Cretaceous Lamellibranchia of England, Vol. II, Part 3; by Henry Woods, M.A. pp. 97–132, pls. xii–xix.
4. The Lower Palæozoic Trilobites of the Girvan District, Ayrshire, Part III; by F. R. Cowper Reed, M.A., F.G.S. pp. 97–186, with title-page, index, and pls. xiv–xx.
5. British Cambrian Trilobites, Part I; by Philip Lake, M.A., F.G.S. pp. 1–28, pls. i–ii.
6. British Graptolites, Part V; by Gertrude L. Elles, Sc.D., and E. M. R. Wood (Mrs. Shakespear), D.Sc. Edited by Charles Lapworth, LL.D., F.R.S., etc. pp. lxxiii–xcvi, 181–216, pls. xxvi–xxvii.

THIS Society has just issued its sixtieth annual volume for December, 1906, which still maintains its high reputation for the excellence of its monographs and the accuracy and beauty of its illustrations.

The fifty-ninth volume appeared in November, 1905, and contained the fossil Cretaceous Echinodermata, by W. K. Spencer; the Cretaceous Lamellibranchia, by H. Woods; the Carboniferous Lamellibranchia, by Dr. W. Hind; the Inferior Oolite Ammonites, by S. S. Buckman; and the Cornbrash Fauna, Part I, by the Rev. J. F. Blake. With regard to this last work, it is with deep regret we refer to the sad loss the Society has sustained by the death of the Rev. J. F. Blake, whose monograph on the Fauna of the Cornbrash had only been commenced in 1905 (see obituary, Geol. Mag., September, 1906, pp. 426–431).

1. Professor S. H. Reynolds' monograph on the Pleistocene Bears is a welcome contribution to our knowledge of the fossil remains of a group of animals widely distributed over the temperate and colder regions of the Northern Hemisphere, and very well represented in the Pleistocene deposits and cave fauna of this country and Ireland.

The author records 33 localities in peat, brickearth, and river deposits which have yielded Bear-remains. Of these only one spot, the brick-earth of Barrington, near Cambridge, has furnished undoubted remains of *Ursus spelæus*. Four other doubtful localities are recorded; one of these, Ilford, may possibly prove, like Barrington, to yield remains of this more ancient type of Cave-bear.

Eleven localities are cited in which the 'Brown-bear' (*Ursus arctos*) has been met with, and two others are doubtfully referred to this species.

The 'great Grizzly Bear' (*Ursus horribilis*) is recorded from 14 localities and from 7 others doubtfully.

Our Limestone caves and fissures in 23 localities have yielded genuine remains of *Ursus spelæus* and 3 others doubtfully; whilst 15 caves have yielded *Ursus arctos*, 14 *Ursus horribilis*, and in 5 other localities the species of bear appears to be doubtful.

The author discusses very fully the difficulties which the comparative anatomist encounters in his endeavours to separate specifically the various bears of the *arctos* type, and cites the opinion of A. E. Brown (Proc. Acad. Nat. Sci. Philad., 1894, p. 119) that "a critical survey of the cranial and dental characters shows little that is constant, except variation, and absolutely forces the conclusion that there is not one character sufficiently stable and uniform to be of specific value. The European bear and the grizzly run into one another so regularly that, except in extreme cases, there is no possibility of distinction apart from geographical considerations."

"The differences," writes Professor Reynolds, "separating the cave bear (*Ursus spelæus*) from the others are certainly greater than those between the different bears of the *arctos* type, but, unless perhaps in the case of pm. 4, it is doubtful whether they are sufficiently marked and constant to afford specific distinctions. Certainly all the species of Pleistocene bears are closely allied and tend to run into one another, and it is perhaps not a matter of much practical importance whether they are grouped as one, two, or three species. On the whole it has seemed most satisfactory to recognise the specific distinction of *U. spelæus*, while grouping all the other Pleistocene bears as *U. arctos*." (p. 32.)

2. Dr. R. H. Traquair continues his monograph on the Fishes of the Old Red Sandstone of Britain, and deals with the curious genus *Bothriolepis*, a restored outline by the author of the dorsal surface of *B. hydrophila* being given on p. 125, and five plates, which furnish the details of a number of historical specimens, including those from the famous Hugh Miller Collection.

3. Mr. Henry Woods continues his most desirable work on the Cretaceous Lamellibranchia of England, dealing in the present part with the Pinnidæ, Astartidæ, Carditidæ, Crassatellitidæ, and Cyprinidæ. The 8 plates, by Mr. T. A. Brock, illustrating these

families of Cretaceous bivalves, are most excellent, and their processing and printing by the London Stereoscopic Co. most praiseworthy.

4. Mr. F. R. Cowper Reed contributes a third part of his monograph upon Girvan Trilobites (Lower Palæozoic) from Mrs. Gray's collection. This collection of fossils, from the Ordovician and Silurian rocks of Girvan, Ayrshire, has already engaged the attention of the late Dr. Thomas Davidson (who studied the Brachiopoda), of Professor Lapworth, Professor H. A. Nicholson, Mr. Etheridge, and several other well-known palæontologists, and is now occupying Mr. Reed's attention in describing the Trilobites. It will be remembered that on February 20th, 1903, the Council of the Geological Society awarded the balance of the Murchison Fund to Mrs. Gray in recognition of her labours during very many years in carefully collecting the fossil remains of this district, thus giving to her collection the mark of the Society's approval and commendation. The careful gathering together of the fossils from a given horizon and locality cannot fail to be of the very greatest value to palæontological science. Seven plates, comprising figures of the genera *Lichas*, *Acidaspis*, *Encrinurus*, *Cybele*, *Dindymene*, *Calymene*, *Cheirurus*, *Phacops*, *Asaphus*, *Cyclopyge*, *Ampyx*, and *Illænus*, well executed by Miss G. M. Woodward, illustrate the subject of the present memoir.

5. Mr. Philip Lake commences a monograph of the British Cambrian Trilobites in this volume, which will carry on the work so long left unfinished by the late J. W. Salter. This will be of great importance to collectors and geologists, as the Trilobites occupy so large a place in the fauna of the Palæozoic rocks, and are also extremely valuable in marking off the horizons of the older rocks. Two plates only of the genus *Agnostus* accompany the present part, but they are extremely good illustrations of process-reproduction.

6. The sixth and final memoir is by Miss Gertrude L. Elles, Sc.D., and Miss Ethel M. R. Wood, D.Sc. (now Mrs. Shakespear). These ladies, with the assistance of Professor Lapworth, have reached the fifth part of their monograph, and now deal with the species of the genus *Climacograptus*, illustrated by two plates and numerous text-figures. All workers at this difficult group, the specimens of which are often very obscurely to be seen upon the surfaces of black shale, will be most thankful to the authors for the great pains they have bestowed upon the delineation and description of these organisms, which, when accurately determined, prove of such value to the stratigraphical geologist in fixing the various horizons of the very complex series of older formations of which they are the unerring landmarks and guides.

We commend the work carried on by the Palæontographical Society to the attention of all students of geology, feeling sure that its monographs need only to be known in order to secure new annual subscribers, the better to carry on successfully the important and most valuable work of illustrating and describing every British fossil, and thus to aid in the progress of Palæontology. We may add that Dr. Arthur Smith Woodward, F.R.S., the Secretary, will be happy to receive the name of new subscribers *at any time*. His address is Natural History Museum, Cromwell Road, London, S.W.

II.—The Glacial History of Nantucket and Cape Cod: with an argument for a fourth centre of Glacial Dispersion in North America. By J. Howard Wilson, A.M., Ph.D. 7x + 90 pp., with 38 plates (29 photographic views and 9 maps) and 13 text-figures. (New York, The Columbia University Press; London, Macmillan & Co.: 1906. Price not stated.)

THIS book, issued as No. 1 of the Columbia University Geological Series, is essentially a geological 'paper' of the usual type, published in a form unusual in this country. It is well printed on thick unglazed paper, profusely illustrated, and neatly bound; but the subject-matter, though scientifically valuable, is of comparatively restricted interest, and except in the United States would not have been deemed sufficient either in quantity or substance to reach the dignity of separate publication in this form.

The paper deals exhaustively with the glacial deposits—the only visible formation — of the small island of Nantucket and of the adjacent peninsula of Cape Cod, with notes on other islands in the neighbouring part of the Massachusetts coast. This area had been previously investigated by Shaler, Woodworth, and others, but the author believed that the field was rich enough to yield a second crop. The principal outcome of his work is the theoretical conclusion—of interest mainly to the American glacialist—that the latest glaciation of the region was effected by an ice-sheet radiating from a hitherto unrecognized centre, lying to the east of the Labrador sheet and moving south-westward to the Massachusetts coast from Newfoundland.

The shelly drift of Sankaty Head, Nantucket, receives particular notice, the author having obtained by excavation a large series of shells and a fully detailed section of this stratified deposit of sand and gravel. He has previously published an account of this work in the *Journal of Geology* (Nov.–Dec., 1905); his conclusion being that the beds are of normal marine accumulation, and that although the shelly deposit is only 8 feet in thickness it embraces indications of changing condition; the lower layers containing shells of a shallow-water type and distinctly southern range, while the upper layers denote considerably deeper water and hold a decidedly northern fauna. The shell-beds are supposed to indicate an Interglacial episode, but the evidence on this point is admittedly weak, as the underlying clay is no longer visible; and though considered by the author to be probably of glacial origin, this clay has been assigned by some of the previous workers to the Cretaceous system.

In view of the much-discussed problem as to the level of the land during the Glacial period, it is interesting to note that "from evidence gathered all over the island we know that the land stood not far from its present level when the ice-front occupied the Nantucket position" (p. 30).

In his general discussion of the drift, the author recognizes as the principal features in Nantucket geology — (1) a chain of "Kame Hills," evidently an old line of moraine, which does not, however, mark the extreme limit reached by the ice-sheet; (2) "the fosse," a low area in front of the Kame Hills, supposed to have resulted from the presence of the marginal ice; (3) "the ice-contact slope," rising

above the fosse at the side opposite to the Kame Hills: "here the ice-front rested as the apron-plain developed in front from the overwash, and this slope thus marks the actual front of the ice at any point" (p. 31); and (4) "the apron-plain," sloping gently away from the top of (3) and built up of sandy and gravelly material by streams issuing from the front of the glacier. These features are traced across Nantucket, though not uninterruptedly; and their general aspect is well shown in numerous photographic plates. Of these features the first and the last may be recognized in the lowland drifts of many parts of our own Islands; but "the fosse" and "the ice-contact slope" appear to be unknown, or at any rate have hitherto escaped recognition. In the interpretation of drift-features, however, so much depends upon the foreknowledge of the investigator, that if the attention of our glacialists be turned to the search it is possible that some representative configuration may yet be found in our drifts, though likely, in any case, to be of local and restricted occurrence.

The presence of a fresh-water lake ("Lake Shaler") held in between the lobes of the retreating ice-sheets, is postulated to explain the late-glacial phenomena of the Cape Cod region; and a full consideration of this matter occupies one of the later chapters of the book. Finally, the treatise, thesis, or book contains a lengthy bibliography, but no index.

G. W. L.

III.—On a Section in a Post-Glacial Lacustrine Deposit at Hornsea. By T. Sheppard.[1]

DURING the past few years the various sections in post-glacial lake-beds on the Holderness coast have disappeared, as a result of the erosion of the cliffs, and it has been exceedingly difficult to obtain details of the various beds in consequence. During the Spring of the past year, however, several on-shore gales resulted in a sea-wall in front of the promenade at Hornsea being demolished, behind which was exposed an exceptionally fine series of clays, marls, peat, and gravel, representing the bed of an ancient mere. This was evidently at one time beneath a sheet of water similar to the present Hornsea Mere. Lists of remains of plants, fresh-water shells, Coleoptera, etc., are given, and the fauna and flora of the old and modern meres compared.

REPORTS AND PROCEEDINGS.

Geological Society of London.

January 23rd, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communication was read:—

"On the Geology of the Zambezi Basin around the Batoka Gorge (Rhodesia)." By George William Lamplugh, F.R.S., F.G.S. With Petrographical Notes by Herbert Henry Thomas, M.A., B.Sc., F.G.S.

This paper contains an account of the physiographical and geological structure of the hitherto undescribed country bordering the Batoka

[1] A paper read in Section C (Geology) at British Association Meeting, York, 1906.

Gorge, which was investigated by the author in 1905, under the auspices of the British Association.

The physical features of the country fall into two well-marked divisions:—(1) The unbroken plateau, a portion of the great central basin-plain of South Africa. (2) The area of rejuvenated drainage, a wedge-shaped tract having its apex at the Victoria Falls, due to the lowering of the trunk-drainage by the erosion of the deeply cut gorge.

The following rock-systems are described:—

5. Kalahari Sands, Chalcedonic Quartzite, and other surface-deposits.
4. Flaggy Sandstone of Boomka.
3. Batoka Basalts.
2. Wankie Sandstones and Coal-measures (= Matobola Beds and ? Escarpment Grits of Molyneux).
1. Fundamental Complex of Metamorphic and Igneous Rocks.

(1) The Fundamental Complex was studied *in situ* only at one point, near the Wankie Coal-mine. The position of its outcrop north of the Zambezi is inferred from the character of the river-borne detritus in some of the stream-beds.

(2) The Wankie Series consists of massive sandstones and pebbly grits, containing boulders near the base, with intermediate flaggy sandstones and shales with coal-seams. This series is abruptly truncated on the south-east side, along the Deka River, by a great fault which brings in the Batoka Basalts; but reasons are given for supposing that beds of similar character reappear at the northern margin of the Basalts, north of the Zambezi, beyond the district examined.

The Deka Fault is described in some detail, and its important influence upon the structure of the country is discussed. It is suggested that the 'Sijarira Quartzites' of Molyneux, of the country farther to the north-east, may be only the indurated and contorted sandstones that accompany this great fault.

(3) The Batoka Basalts were found to extend unbrokenly from the Victoria Falls eastward to the mouth of the Deka, and southward to the edge of the Kalahari Desert; and it is shown that they also cover a very wide area to the southward and westward of the region traversed. They consist of a succession of massive lava-flows and flow-breccias; no intercalated sediments were found in the districts examined, nor was any eruptive centre discovered. Some curious structures observed in basalts are described; and it is remarked that the zigzagging character of the stream-gorges below the Victoria Falls is due to the differential erosion along the strong joints and fault-planes in these rocks, under the alternating conditions of wet and dry seasons.

The age of the Basalts is discussed, and it is considered that they are probably Mesozoic, and may date back to the later stages of the period of volcanic activity represented by the Stormberg Beds of the more southerly part of the continent.

(4) Some limited patches of Flaggy Sandstone, etc., seen near the head of the Deka Basin, appear to represent sediments newer than the Basalts, and may be equivalent to part of the Forest Sandstone of Mr. A. J. C. Molyneux and Mr. F. P. Mennell.

(5) The 'Kalahari Sands,' which cover large areas of the plateau, occur mainly in broad low swells or 'bults' of friable red sand, now tree-clad. These sweep down to the Zambezi River in the shallow valley above the Victoria Falls, and cannot have been accumulated under existing conditions. The author endorses Dr. S. Passarge's view that they indicate a former period of greater aridity than the present in the Central Basin.

Some irregular patches of surface quartzite and limestone, due to the percolation and evaporation of ground-water, are described and compared with the 'Botletle Schichten' (Passarge) of the Kalahari, but the author considers that the antiquity of these beds is not so great as that assigned to the 'Botletle-Schichten.'

The paper concludes with a petrographical appendix by Mr. H. H. Thomas, giving the results of his microscopic examination of a series of rock-specimens collected by the author.

CORRESPONDENCE.

THE ASHGILLIAN SERIES.

SIR,—In connection with Dr. Marr's paper on the Ashgillian Series in this month's GEOLOGICAL MAGAZINE, it may be of interest to call attention to some further evidence of the age of the Starfish Bed in the Drummuck Series of Girvan which he correlates with the *Staurocephalus* Limestone of the north of England and Wales. To the list of trilobites from this bed which I have recently given in my monograph on the Lower Palæozoic Trilobites of the Girvan District (Palæontographical Society, 1903–1906) there may now be added the two species *Cheirurus Keisleyensis*, Reed, and *Ampyx binodulosus*, Reed, described by me in 1896 from the Keisley Limestone. Mrs. Gray collected these specimens within the last few months, and they have only lately come into my hands for identification. The affinities of the trilobitic faunas of the Keisley Limestone and Starfish Bed which had been previously observed are appreciably strengthened by these new discoveries.

F. R. C. REED.

SEDGWICK MUSEUM, CAMBRIDGE.
February 20th, 1907.

OBITUARY.

EDWARD BEST.

BORN DEC. 20, 1824. DIED NOV. 8, 1906.

WE regret to record the death on November 8th, 1906, of Edward Best, who for more than thirty-eight years was Resident Geologist to the Geological Survey in Jermyn Street. Born on the 20th December, 1824, he joined the service in January, 1855, shortly before De la Beche died, and he retired on March 31st, 1893. Although he never took a profound interest in geology, he was ever ready to give help to those who sought information at the Geological Survey Office, while his ever cheerful disposition and *bonhomie* endeared him to all who came to know him.

JOHN WARD, F.G.S.

Born August 11, 1837. Died November 30, 1906.

The death of Mr. John Ward, of Longton, Staffordshire, removes from the Midlands one of its best known and most active geologists and palæontologists. Mr. Ward devoted the leisure of his busy life to a detailed study of the North Staffordshire Coalfield and its fossils. He was a pioneer in the collection of fossils to illustrate accurately their zonal distribution; and he met with great success not only in unravelling the stratigraphy of the Coal-measures, but also in the discovery of a large number of well-preserved fossil fishes, which were new to science and contributed to a great advance in our knowledge of Palæozoic Ichthyology.

Mr. Ward was born at Fenton, North Staffordshire, in 1837, and was educated at Ivy House School, Hanley. Early in life he entered on a business career, which occupied him until the end, and only left him scanty leisure for the pursuit of studies. When quite young, he came under the influence of Dr. Robert Garner (author of the well-known "Natural History of the County of Stafford," 1844), who encouraged him in the geological researches which became the main recreation of his life. In 1865 he attended the meeting in Stoke at which the North Staffordshire Field Club was established, and continued for forty years to be one of its most active members.

Mr. Ward's geological researches had as their chief aim the identification and correlation of the more important coal-seams of North Staffordshire by their fossils; and one of his earliest discoveries was that of marine bands intercalated at definite horizons in the Coal-measure series. His observations were first summarised in 1890 in his exhaustive volume on "The Geological Features of the North Staffordshire Coalfields," published by the North Staffordshire Institute of Mining Engineers. His final conclusions formed the subject of some valuable chapters on the "Palæontology of the Pottery Coalfield," which he contributed to the Geological Survey Memoir in 1905.

Mr. Ward was also an accomplished palæontologist and made many important observations on the fossils in his collection, but he rarely attempted palæontological descriptions. His fossil fishes were studied and described by Egerton, Huxley, John Young, James W. Davis, Dr. Traquair, and the present writer, some of the most important researches of Dr. Traquair having been based almost entirely on the specimens obtained from the Coal-measures of Longton and Fenton. Mr. Ward's name, however, is permanently associated with his discoveries in numerous instances, such as those of *Acanthodes Wardi*, *Listracanthus Wardi*, *Mesolepis Wardi*, *Rhadinichthys Wardi*, and others. The Lower Carboniferous Platysomid genus *Wardichthys* is also named after him.

When, by the closing of certain coal-pits, opportunities for collecting fossil fishes became fewer, Mr. Ward decided to offer his collection to the British Museum, and the principal part of it was purchased by the Trustees in 1894. After that year he devoted attention more especially to the Mollusca and Plants, which were described respectively by Dr. Wheelton Hind and Mr. R. Kidston; though he still never

neglected any opportunity of obtaining fish-remains, and among these his latest most important discovery was that of a new *Listracanthus* in direct association with the so-called *Petrodus*.[1]

Mr. Ward was elected a Fellow of the Geological Society in 1874, and received a moiety of the Lyell Fund from that Society in 1899 in recognition of the value of his long-continued researches. In 1895 the North Staffordshire Field Club also honoured him by the award of the Garner Memorial Medal. Only a small proportion of Mr. Ward's work, however, is embodied in his published writings. He was an unassuming and unselfish, enthusiastic student, whose knowledge was at the disposal of everyone who went to consult him. The little library in the room above his shop, and the dark basement in which he kept his collection for so many years, were the familiar haunts of all who were interested in the English Coal-measures. His robust physique enabled him to participate in active field-work almost until the end of his life, and he was always ready to accompany enquirers to any part of the district he knew so well. His genial presence will be missed by a large circle of friends who mourn his loss.

A. S. W.

List of Papers by John Ward, F.G.S.

1861. "Fenton Park: its Ichthyolite Remains": Potteries Mechanics' Mag., vol. ii, p. 137.

1865. Letters on "Marine Fossils in Coal-measures": Geol. Mag., Dec. I, Vol. II, pp. 234, 286.

"The Distribution of the Organic Remains of the North Staffordshire Coalfield": Trans. Dudley and Midland Geol. Soc., vol. ii, p. 21.

1870. "Notes on the Fossil Trees in Messrs. Hampton's Marl Pit at Joiners' Square, Hanley": Rep. N. Staffs. Nat. Field Club.

"The Fossil Fishes of the North Staffordshire Coalfield": Trans. Midland Sci. Assoc., pt. ii.

1875. "Notes on the Fossil Trees in a Marl Pit at Hanley": Addresses and Papers N. Staffs. Nat. Field Club, pp. 80–86.

"On the Organic Remains of the Coal-measures of North Staffordshire, their Range and Distribution, with a Catalogue of the Fossils and their Mode of Occurrence": loc. cit., pp. 184–251, with plate.

1878. "Notes on some Fossil Trees in a Marl Pit at Joiners' Square, near Hanley": Rep. N. Staffs. Nat. Field Club.

1880. The same, with further notes: loc. cit.

1889. "The Lower Coal-measures of the Cheadle Coalfield, with Special Reference to the Recent Boring for Ironstone at the Park Hall Colliery, Cheadle": loc. cit., pp. 88–91.

1890. "The Geological Features of the North Staffordshire Coalfields; their Organic Remains, their Range and Distribution, with a Catalogue of the Fossils of the Carboniferous System of North Staffordshire": Trans. N. Staffs. Inst. Mining Engineers, vol. x, pp. 1–189, pls. i–ix.

1893. "The Progress of Geological and Palæontological Research in North Staffordshire, with Summary of Literature relating to the Geology, Mineralogy, and Palæontology of North Staffordshire": Trans. N. Staffs. Nat. Field Club, vol. xxvii, pp. 67–107 (continued in vol. xxix, 1895, pp. 105–106).

1895. "On the Occurrence of Marine Fossils in the Coal-measures of North Staffordshire": loc. cit., vol. xxix, pp. 129–138.

1900. "On a newly-discovered Marine Bed in the Coal-measures of North Staffordshire": loc. cit., vol. xxxiv, pp. 87–92.

1905. "Palæontology of the Pottery Coalfield": in "The Geology of the North Staffordshire Coalfields," Mem. Geol. Surv.

[1] A. S. Woodward, "On the Carboniferous Ichthyodorulite *Listracanthus*": Geol. Mag., Dec. IV, Vol. X (1903), pp. 486–488, with figs.

1906: [With JOHN T. STOBBS.] "A newly-discovered Fish Bed in the Cheadle Coalfield; with Notes on the Distribution of Fossil Fishes in that District": Trans. N. Staffs. Nat. Field Club, vol. xl, pp. 87–101, pl. i. "Palæontology of the Cheadle Coalfield": loc. cit., vol. xl, pp. 102–137, pl. ii.

CAROLINE BIRLEY.

BORN NOVEMBER 16, 1851. DIED FEBRUARY 15, 1907.

By the death of Miss Caroline Birley a most ardent and enthusiastic student has been lost to the science of Geology, one who from her childhood to the end of her life never wavered in devotion to this her cherished pursuit, nor thought any fatigue or personal sacrifice too great in order to visit places of geological interest and obtain specimens for her beloved Museum.

Caroline Birley was the youngest daughter of Mr. Thomas Hornby Birley, who resided at Hart Hill, near Manchester. When a child her holidays were constantly spent in the Isle of Man, where her grandfather, Lieut.-Col. Leatham, resided after his retirement from the Army. Her earliest delight was to select specimens of stones showing any peculiarity, and when about 9 years of age she commenced to form a collection, to which she continued most assiduously to add when travelling in England or on the Continent. When the GEOLOGICAL MAGAZINE commenced its existence in 1864 this young enthusiast of 13 years of age became a regular monthly subscriber, devoting her pocket-money to this periodical! After a year of self-denial her grandmother, discovering this sacrifice to the cause of geological science, made her granddaughter a special allowance to purchase this coveted journal.

In the year 1888 Miss Caroline Birley's collection had already outgrown the space in her house at Seedley Terrace, Manchester, and she erected an iron building in the garden as a museum. In 1888 Miss C. Birley visited Faxe, Denmark, and again in the Summer of 1891, when she made a large collection of Upper Cretaceous fossils. The Crustacea thus obtained were described by Dr. H. Woodward in the GEOLOGICAL MAGAZINE for November, 1901 (pp. 486–501, Pl. XII). Two new species of the genus *Dromiopsis* (*D. Birleyæ* and *D. Coplandæ*) obtained in that expedition were figured and described by him, and dedicated to Miss C. Birley and her friend and fellow-traveller, Miss L. Copland.

In June, 1889, Miss Birley and her friend Miss Copland visited the Færoes, bringing back from the islands of Stromoe, Naalsoe, and Osteroe six hundredweights of rocks containing zeolites. In 1890 she paid a second visit to the Færoes. In that year Miss Birley became a member of the Geologists' Association, to the excursions and meetings of which Society she was always afterwards a very constant attendant. She also, later on, in 1894, joined the Malacological Society of London, and frequently attended its meetings. In November, 1891, Miss Birley and Miss Copland went to Malta and did a considerable amount of collecting from the Tertiary strata of that island. In 1892 the ladies visited Algeria, but did not succeed in making a very large collection there.